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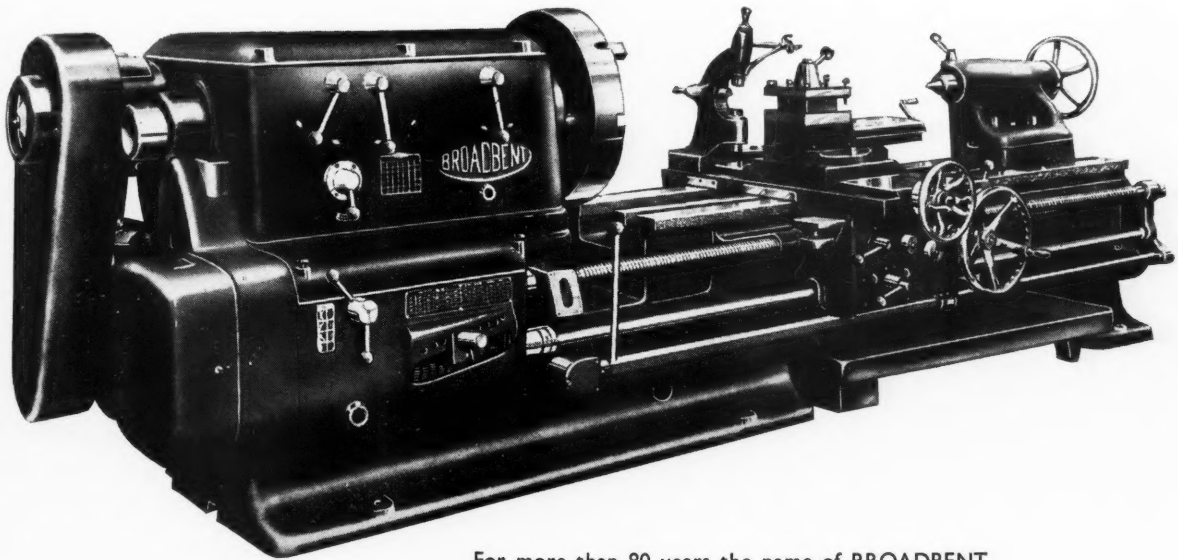
BROADBENT *Lathes*



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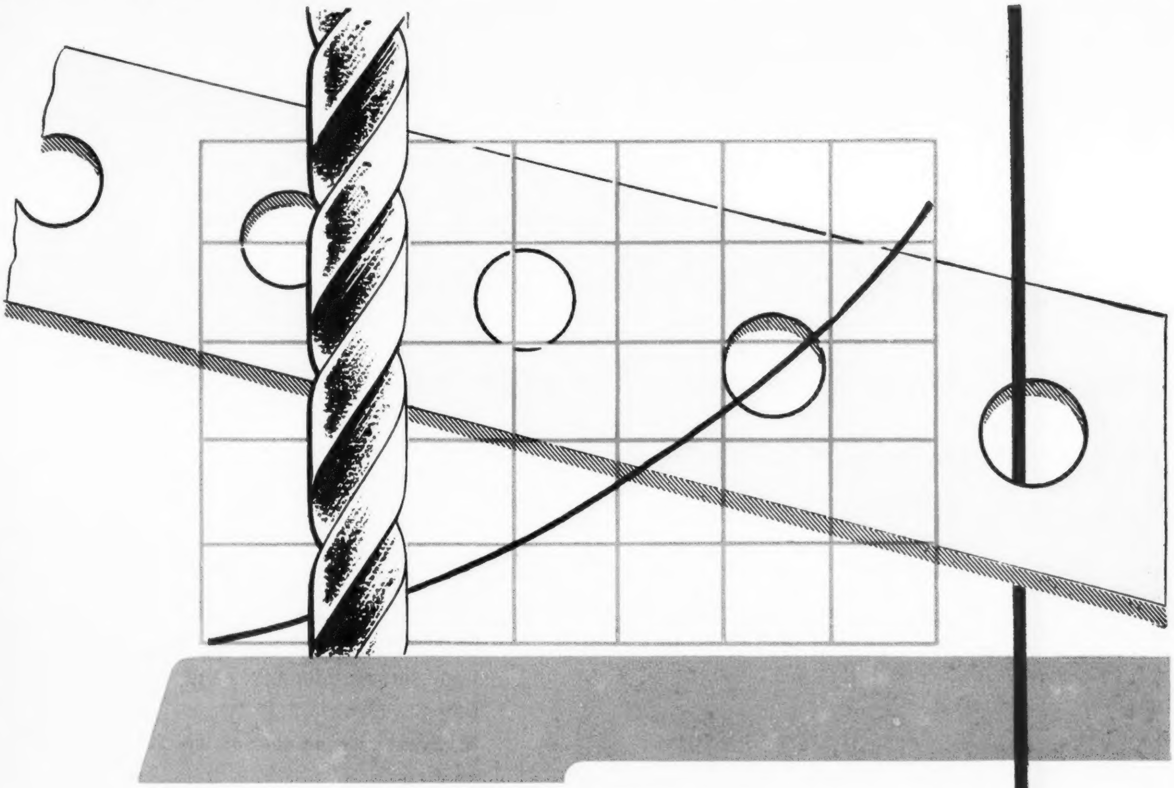


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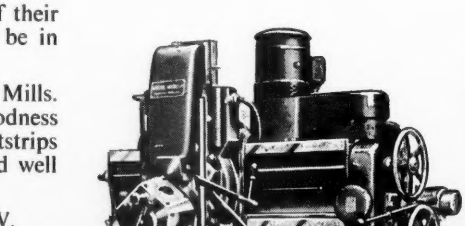

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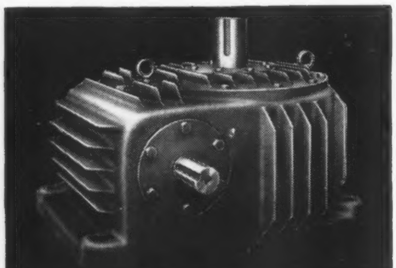

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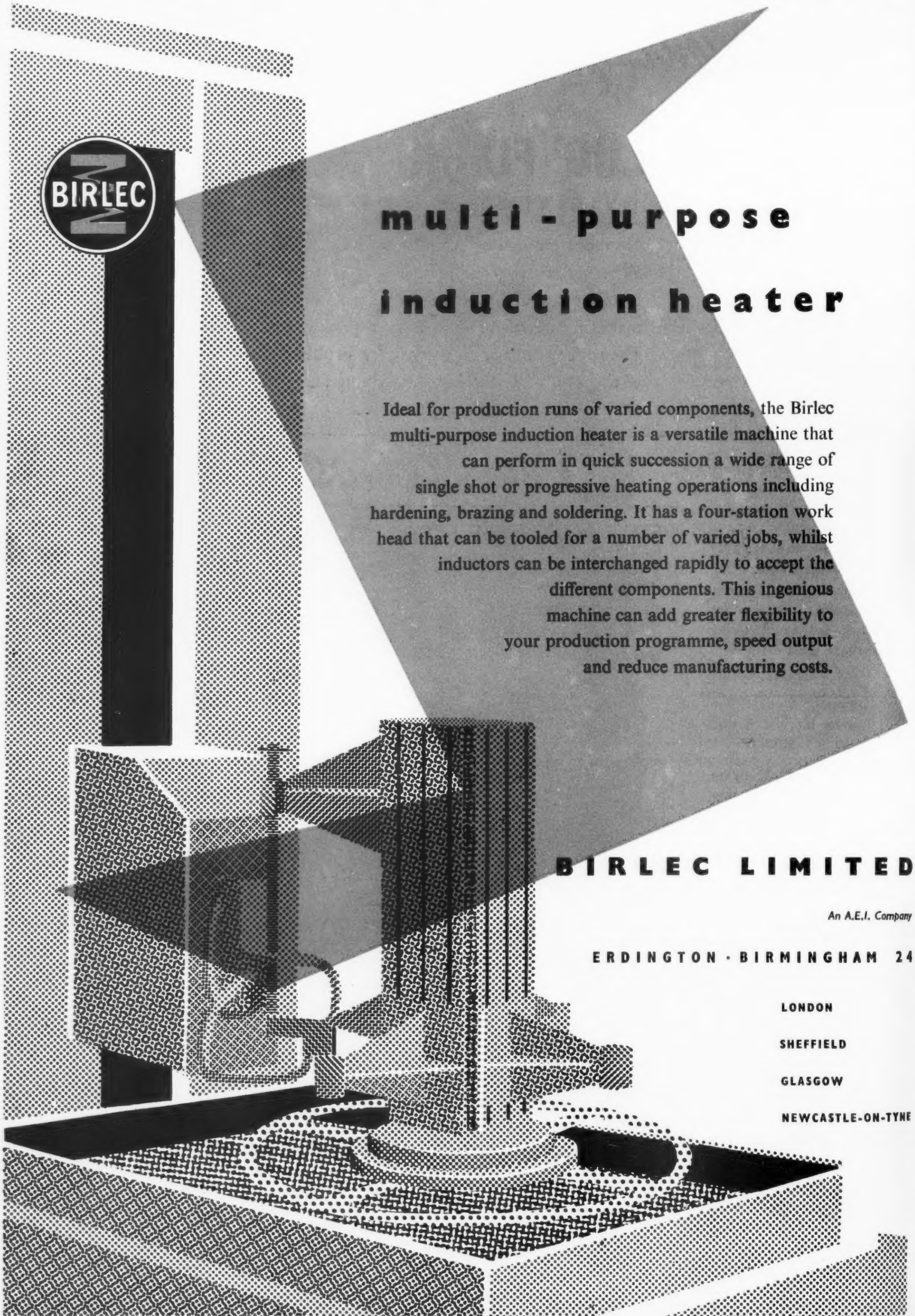
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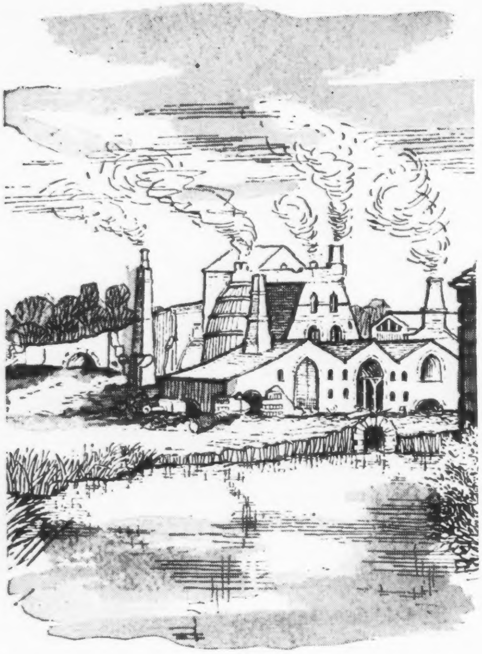

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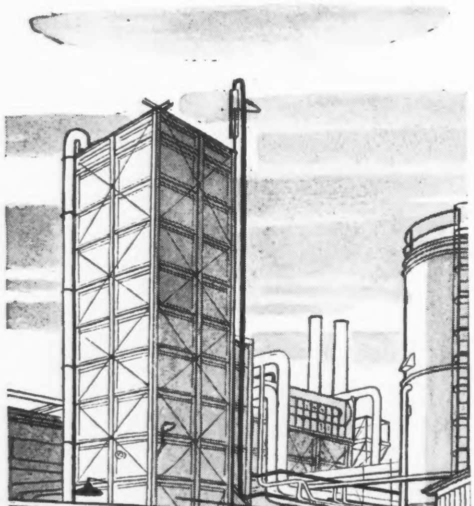

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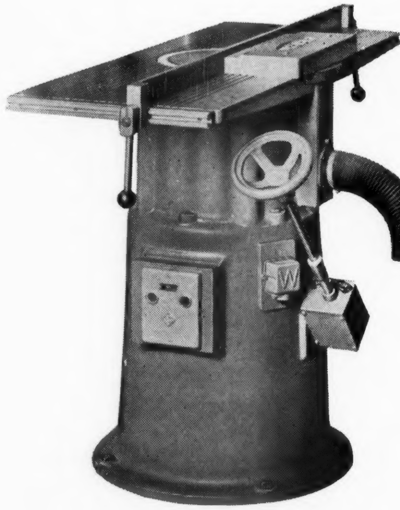

The Harrogate Conference

FIRST PLENARY SESSION

1st July, 1957

IN declaring the Conference open, at 9 a.m., on 1st July, in the Royal Hall, Harrogate, Mr. E. W. Hancock, M.B.E., said that, as outgoing President, he wished to extend a most hearty welcome to all those attending the Conference, and to the wives and families accompanying them. He offered a special welcome to the visitors from overseas, who had come from Sweden, Norway, Holland, France, the United States of America and Australia. The Institution was an international one, and it was particularly pleasant to welcome so many overseas delegates. One whom they were particularly pleased to see was Dr. Lillian Gilbreth, from the United States. They were all delighted to have her present to represent her great country. (*Applause.*)

After opening the Conference, the first duty which he had to perform was to install the new President. In fact, Father Time had already done so ; as the midnight bells died away, Time brought in Lord Halsbury as President of the Institution, and all that remained to be done was to install him in a rather more human way.

Mr. Hancock wished to make a few references to his own experience as President before handing over to Lord Halsbury. It was with mixed feelings that he concluded his term of office as President of the Institution. It had been a wonderful year for him, full of interest and inspiration. He had seen not only the excellent work at Head Office, but the work on the shop floor. The Institution was made up of its Sections, and he had had the privilege of visiting them — of going to the 'shop floor', as he called it — to see the work of the Institution there.

In attending over 40 functions on behalf of the Institution, and visiting more than 14 Sections, he had been impressed by the wonderful work which was being done not only on behalf of the members of the Institution, but on behalf of the country as a whole. In its development towards a more scientific approach to production and technical education, the Institution was doing a wonderful job. He had found, at the various lectures for which he had taken the chair,

and at others which he had given, a keenness on the part of the audience, whether members of the Institution or not, to absorb the latest ideas, which were discussed by the Institution throughout the country.

Mr. Hancock then referred to a few of the highlights in the Institution's activity during the past year. In July, 1956, there had been the Summer School at Ashorne Hill, with the theme, "Education for Automation". In September, the first Materials Handling Convention had been held at Leamington. In October, the Institution held its Annual Dinner, at which the principal guest had been The Rt. Hon. Iain Macleod, P.C., Minister of Labour. It had been a great joy to Mr. Hancock on that occasion to see the 1956 Schofield Scholarship Award made to Mr. Harold Scholes. In the same month, the Viscount Nuffield Paper had been presented at Bristol University by Dr. Grey Walter, on "Thinking Machines". In November, the Sir Alfred Herbert Paper had been presented at the Manchester College of Science and Technology, by Dr. B. V. Bowden, who dealt with "The Development of Technological Education in Europe, America and England".

He had mentioned the name of Sir Alfred Herbert, a Past President of the Institution. Sir Alfred had passed away during the year, and Mr. Hancock suggested that they should pause for a moment with heads bowed in memory of a great man, and in memory of another great man in the Institution who had passed away, Mr. Tom Fraser, C.B.E.

After a short pause, the Chairman went on to say that in December the Institution had given assistance to the Department of Scientific and Industrial Research in making a film in the form of a case study, showing how improvements in productivity had been effected in a firm by one of the executives who had attended a conference. That case study had been a true one, and this was worth emphasising; the executive was a member of the Institution, and the conference one on compressed air organised by the Cornwall Section in 1955. Several of the film sequences took place at the Head Office of the Institution.

In January, 1957, the fifth of the Annual Aircraft Production Conferences had been held at Southampton, on "New Materials and Methods". It had been opened by the then Minister of Supply, and the first Lord Sempill Paper had been presented on that occasion. In March, the George Bray Memorial Lecture had been delivered at the City Hall, Sheffield, on "The Scope for Operational Research in Industry". Well over 600 people had listened to that enlightening lecture, people who were searching for something new and looking ahead.

There had been many discussions with kindred institutions, one of the most important during the year being a discussion with the other leading professional institutions on the setting up of the first national body on automation, under the

title of the British Conference on Automation and Computation. That was a most important step forward, in which all the professional institutions, the Institution of Production Engineers being one, put their names to that most important agreement.

In April, there had been the formation of the first specialist group in the Institution, on Materials Handling, arising out of the activities of the Materials Handling Sub-Committee of the Institution's Research Committee. In the same month, the Midland Management Conference had been held at Droitwich in conjunction with the B.I.M. In April, too, the new Education and Technical Officer of the Institution had been appointed. In May, there had been the Annual Conference of Standards Engineers in London, jointly with the British Standards Institution and, finally, there was the present Conference at Harrogate.

In going round the country as he had done, and having the great privilege of talking to his fellow-countrymen, he found that his main theme throughout had been fairly consistent and had followed the same pattern. He would, therefore, like, briefly, to repeat what he had said from time to time.

First, he had called on his fellow-countrymen to stop the foolish habit of running Great Britain down. He had also, and very successfully, made it known throughout the country that the British youth of today was just as good as ever it had been. Thirdly, he had emphasised that, despite all political differences, those in this island should and must pull together.

One of his personal highlights during the year had been signing the certificates of new members, and nothing had pleased him more than to sign no fewer than 400 Graduate certificates. It had been a thrill to sign them, knowing the very high standard of the examination which those young men had had to pass in order to qualify.

Mr. Hancock said he would like to thank everybody for the kindnesses extended to himself and to his wife. First, he thanked the Head Office staff. He named Mr. Woodford, Mr. Caselton and Miss Bremner as only three, but all of them had been most kind to him during his term of office. They were all doing a very good job of work.

He thanked the Region and Section officers, and particularly the Chairmen, Secretaries and Committees, for the wonderful work which they were doing and for the kindnesses shown him during his many visits to their Regions and Sections. He thanked also all the members of the Standing Committees, who did such excellent work on behalf of the Institution. He had found, in going about the country on behalf of the Institution, an unselfish enthusiasm which had been inspiring. He wished particularly to thank the ladies. In his visits to various parts of the country they had been most kind to his wife and himself, and he

had been able to appreciate more than ever the important part which the ladies played in helping their menfolk to give unselfishly of their time in the interests of the Institution. He would like to take the opportunity of thanking his wife for the support which she had given him over many years in the interests of the Institution, and particularly during his term of office. He thanked also his private secretary, Miss Brown, and finally he thanked his sponsors once more for giving him the opportunity of enjoying what had been a wonderful year of office as President of the Institution.

In handing over his office to such an illustrious person as The Rt. Hon. The Earl of Halsbury, he did so with the knowledge that he was handing over not only a responsibility, but a very high honour. Lord Halsbury was already famous in his many other activities and, now that he was accepting the high office of President of the Institution, Mr. Hancock wished to thank him on behalf of the Institution, in the knowledge that he would carry on the work of the Institution to the very highest standards.

Investing the new President with his badge of office, Mr. Hancock said: "Lord Halsbury, in the symbolic action of placing the badge of office on your shoulders, I convey to you the gratitude of us all, and wish you every possible success and happiness in your term of office." (*Applause.*)

The President (The Rt. Hon. The Earl of Halsbury, F.R.I.C., F.Inst.P., M.I.Prod.E.) in response thanked the Council of the Institution of Production Engineers for the confidence which they had shown in him by investing him with the symbol of his high office, and thanked Mr. Hancock for the very felicitous terms in which he had handed it to him. This was perhaps an occasion, he

(*concluded on page* 487)

Mr. Hancock, retiring President, congratulates Lord Halsbury as he takes office.

"Automatic Production – change and control"

CONFERENCE, HARROGATE, 30th June - 3rd July, 1957

Continuing the publication in the Journal of Papers presented at the Conference, this issue contains the following :-

FIRST PLENARY SESSION

"The Administration of Modern Production" by the Rt. Hon. The Earl of Halsbury, F.R.I.C., F.Inst.P., President of the Institution.

DISCUSSION GROUP A1

"The Effect of Automation on Management Organisational Principles and Practices" by Dr. Lillian Gilbreth.

DISCUSSION GROUP B2

"Product Design for Automated Production" by D. L. Johnston, B.Sc.(Eng.), A.M.I.E.E., M.S.I.A.

DISCUSSION GROUP A3

"Data Processing Systems as an Aid to Management" by N. D. Hill, B.Sc., A.Inst.P.

THE ADMINISTRATION OF MODERN PRODUCTION

by The Right Hon. THE EARL OF HALSBURY, F.R.I.C., F.Inst.P., M.I.Prod.E.

Lord Halsbury, who takes office on 1st July as President of the Institution for 1957/58, has been since 1949 Managing Director of the National Research Development Corporation, which was set up under the Development of Inventions Act, 1948, mainly to ensure the development and exploitation of inventions resulting from public research.

Born in 1908, Lord Halsbury was educated at Eton, and on leaving went into the City to study chartered accountancy. But he soon turned to science, and as an external student of London University took a B.Sc. degree with first-class honours in chemistry. His first industrial appointment was with Lever Brothers at Port Sunlight.

During the War, at the research laboratories of Firth-Brown, in Sheffield, he worked on the design of special steels for the blades of gas turbines and jet engines. In 1946, he became Research Manager and later Works Manager of the Decca Record Company Limited, where his main research target was the production of gramophone records in unfilled plastic suitable for long playing records with silent surfaces.

Lord Halsbury was a Member of the Advisory Council of the Committee of the Privy Council for Scientific and Industrial Research from 1949/54, and is now a member of its Mechanical Engineering Research Board. He has been Chairman of the Science Museum Advisory Council since 1951. He is also a Deputy Chairman of the Parliamentary and Scientific Committee ; Chairman of the National Institute of Industrial Psychology ; Vice-President of the Royal Institute of Philosophy ; and a member of the Court of Governors of the Manchester College of Science and Technology.

He is a Member of Council of the Royal Institute of Chemistry ; a Member of Council of the Royal Society of Arts ; and a Member of the Grand Council of the British Empire Cancer Campaign.

OUR Conference is concerned with change and control, that is to say, the administration of the most modern production. In administration we are always changing something or else, by control, preventing it from changing spontaneously into something we regard as undesirable. Whether we are initiating something or preventing its spontaneous occurrence, we are controlling. And whenever we control something we do so by reason of a change regarded as desirable or undesirable. Change and control are therefore at the heart of administration.

From of old, administrators have blended experience with intuition. Since I shall have much to say of intuition in the sequel I would like to make it clear what I shall be talking about, so as to remove any mystagogery surrounding its associations. We talk of feminine intuition and we used to talk of Hitler's intuition in terms which left the subject undefined. I shall therefore be concerned to define what I am talking about before going any further.

The intuitively clever person is often said to get the right answer for the wrong reason or to act correctly on insufficient evidence. I believe that expressions of this kind confuse the issue. They

ignore the fact that the intuitionist (as also the rationalist) often gets the answer wrong. One does not get answers right for wrong reasons, though if one is not good at using words (as intuitionists frequently are not) one may misdescribe the reasoning which led one to an answer.

A feature of our Universe is some kind of sentient process of which we know nothing save that it is manifest in association with the brain, particularly the human brain. This association is what we mean when we talk of 'the mind'. The mind is not simultaneously associated with every activity of the brain ; it switches from one brain activity to another. If you are a dualist, you believe that there is an interaction between mind and brain and that each is capable of driving the other like two cog wheels in mesh (the mesh, of course, is not spatial). If you are an epiphenomalist, you believe that the interaction is one way and that mind is a mere spectator driven by the brain's activity. On either view of the matter what the psychiatrist calls the unconscious mind would appear to be the activity of the freely functioning brain. If you are a student of Yogi, you believe that large tracts of the brain and nervous system are almost permanently free from any mental intervention, but that by practice the scope for association of mind and brain can be extended. I mention these matters by way of preliminary clarification.

The brain is analogous to a computer, but of a very special kind. It has a high degree of spatial redundancy and a high degree of autonomy among circuits capable of functioning simultaneously, independently and in parallel.

Consider now a computer functioning according to three alternative programmes :-

1. It receives input, processes the data received and delivers output to a printing device. If a large volume of processing is involved between input and output, this can proceed at the clock speed of the computer which may be very high. It is only the final stage of printing that is limited by the speed of the output device.
2. As above, with the following limitations : the programme requires that on completion of each processing order :
   (a) the number of the order in the instruction register is to be printed out ;
   (b) the contents of the accumulator are to be printed out.
3. As above, with the following additional limitation : the printed-out order number and accumulator contents are to be read and treated as input to the instruction register and accumulator.

It is obvious that any computer operating under programme 2 above would be permanently slowed down to the speed of the output device. A computer operating under scheme 3 would be still further slowed down and, in addition, would be subject to an extra source of error produced by any mistakes involved in re-writing the order number and accumulator contents back where they came from.

When I talk of intuition, I mean a state of affairs in which the brain is operating as in scheme 1 above. A rational decision or argument resembles scheme 2. The mind is locked on to the verbalising process and its data processing is reduced in speed first by the need to abandon the autonomy of the brain's parallel activities, which have to be carried out in sequence, and secondly by the reduction in speed necessitated by locking on to the output device — speech or the suppressed speech-imagery which we call 'rational thinking', though 'verbal thinking' would be a better name for it.

This verbal thinking has its dangers. As we proceed sequentially in the course of a rational argument, the verbal output of one stage becomes the verbal input of the next, and errors can creep in due to the misuse of words. I do not need to elaborate on the analogy this bears to the printing and re-reading errors involved in scheme 3 above. Such errors are the basis of much that we call 'muddled thinking'. They account for the fact that clear working is often an essential prelude to clear thinking. Their elimination is the purpose of the essentially modern discipline called semantics.

Not all our thinking is verbal. When we drive a motor car through traffic or straighten a picture hanging crooked on the wall, we are certainly thinking and thinking consciously, but we are not casting our thoughts into verbal imagery. Our state of mind in such a case probably resembles that of the more intelligent animals, stepped up somewhat in intensity and awareness.

The intuitive mind

An intuitively clever person is therefore a person who has not become over-entangled in the verbal lock-on process. The expert devoid of commonsense is the exact opposite, a person so ensnared in symbols that he cannot detach himself and cope with the external world.

The intuitively clever child may not do well at school. Yet early in life he may make his mark in the world to the astonishment of those who beat him at written examinations a few years earlier. We must not underestimate his innate intelligence because we have a prejudice for measuring it in a way which will assure him low marks.

Now take a look at the world ; at its complexity and its kaleidoscopic changes of fortune and circumstance. Most real situations are too complex to be put into words in real time, to borrow a term from guided missile control. That is to say, one cannot reduce a situation to verbal argument and produce a solution in verbal terms in the time available from the making of a decision. One can, of course, carry out an *ex post facto* analysis after the decision has been made and explain why it was right or wrong, but that is not working in real time.

Is it not clear that under such circumstances an important share in decision-making will belong to those with the intuitive type of mind that I have described earlier ? Is it surprising that they do well in practical affairs ?

Now take a look at the world's administration. You can perceive its history as a prolonged and successful struggle to reduce to verbal discipline situations which start as too intractable to yield to other than an intuitive approach, and which yield finally to verbal control only after an extended rearguard action fought by chaos and old night against the light of reason.

The history of administration is the history of the encroachment of the rational upon the intuitive fields of human activity. Do not, however, imagine that this displaces the intuitively clever person from his important position in society. It displaces his local field, not himself. Regard the intuitionist as the frontiersman, and the rationalist as the settler, and you will have a perspective of their relationship. The settler occupies the territory dominated by the frontiersman a generation back, and the frontiersman pushes on into the new unknown.

A phase of progress

I mention all these matters at some length because in administration, as in many other fields, we are going through a phase of accelerated progress. In such cases, people frequently mistake a transient acceleration for a permanent one and wonder uneasily what will happen if it keeps up for ever. They also tend to confuse a transient acceleration with a discontinuity and evolution with revolution.

I do not believe that we are undergoing a revolution, though the course of evolution has accelerated. If anyone expects me to believe that the intuitively clever person will lose his place in society, I can only deny the soft impeachment. It will take more than computers and automation to change the pattern of a culture and I do not believe our basic culture pattern will change very much in the next generation. The facilities available to it for exploitation will, however, be greatly extended and rationality will encroach markedly upon the preserves of intuition.

No one technique will be responsible for this. A group of independent techniques are frequently lumped together as 'Operational Research'. Another group is referred to as 'Industrial Mathematics'. A third is often called 'Data Processing'. These descriptions are not exclusive. There is a substantial overlap and whenever extensive calculations are involved, an instrument — the computer — will be found in association with them. Not all industrial mathematics are concerned with Operational Research, however, nor does the latter necessarily involve any data processing of a kind which would require a computer.

By 'Operational Research' I mean a situation-analysis undertaken to procure the optimal use of a facility regarded as given for the purpose of the problem. In the historical analysis by means of which Professor Blackett determined how a bomb should be fused, the bomb, the aeroplane and the submarine were given. The setting of the fuse to explode on impact or at some predetermined depth was the only variable which required consideration. His problem was to set the fuse so as to maximise the chances of sinking a submarine by dropping the bomb on it from an aeroplane. The mathematics involved were of a straightforward variety long familiar to mathematical physicists. The originality lay in applying them to a military problem which had hitherto been tackled intuitively. In fact his solution was in flat contradiction to the findings of the intuitionists, but submarine sinkings increased remarkably when it was adopted. Why were the intuitionists so wrong? Intuition, of course, uses experience just as reason does. If that experience lies in a field of good practice, then the intuition based on it is likely to produce good answers. If it lies in a field of bad practice, then answers based on intuition are more likely to be wrong. Wars only occur once a generation and rarely last long enough for much experience to be gained one way or the other. This is the basis for an old wisecrack to the effect that a general's battles are mostly won by the mistakes of the enemy. That is why Blackett's solution contradicted the experience of the military.

In business and technical adminstration there are always fields where the merits of our standard practice are hard or even impossible to assess. We have, therefore, no means of knowing whether our standard practice is good, bad or indifferent. The intuitionist's solutions are in these circumstances likely to form a mixed bag, with himself unable to discriminate good from bad.

Suppose next that we did not take the aeroplane and the bomb for granted in Blackett's problem, but adjoined the resources of the R.A.F. The problem would then be how to use aeroplanes to sink submarines. If the adjunction was a little wider — the resources of the aircraft industry, for instance — the problem would grow in scope and would be concerned with determining the best way of designing aeroplanes for coastal command. Finally, we could adjoin the resources of the nation and ask how they should best be deployed for winning wars. If the war was a cold war rather than a shooting war, the conditions would be somewhat different; we should have to ask how to use resources so as simultaneously to maximise the growth of the economy by minimising the production of obsolete arms in excessive quantities, and nevertheless maximise the security and military preparedness of the nation.

Very broad problems of this character cannot be approached by the relatively simple mathematics which Blackett brought to bear on the submarine problem. No single mathematical technique is characteristic of Operational Research. The choice of weapon from the armoury must depend upon the specific problem requiring solution. I will review a few of these in turn.

Linear Programming. This technique deals with problems which would be trivial if the number of variables involved was small. We want, let us say, to maximise the profit obtainable by operating a factory. The profit is calculable as a profit rate per unit manufactured and sold, multiplied by the number of units involved. The former is regarded as a coefficient in

an equation, the latter as a variable. The graph of total profit against number of units would under these circumstances be a straight line. This is the origin of the term 'linear'. If the variety of goods manufactured is multiple, then the total profit is the sum of the profit on the individual varieties — a linear sum over numbers manufactured.

If we want to maximise this profit, intuition will give the correct answer in simple cases. If only one variety is manufactured, we run the factory for as long as the Union agreement permits and then blow the siren to go home. If an essential supply runs out before the siren goes, we sack the order clerk and the storekeeper before putting the men on short time. Alternatively if many varieties are available for a manufacturing programme, we concentrate on the most profitable until a supply runs short and then concentrate on the next most profitable, and so on. It is less clear how we should proceed when interchangeable facilities shared by or stores used in alternative manufacturing operations impose restrictions on the programme — linear restrictions they are called — so that we cannot have our own way all the time. When the number of varieties manufactured is large and the linear restrictions are of an interlocking character, the determination of a programme may baffle the paper and pencil arithmetic of the works manager.

Suppose we produce 225 bottles equivalent of fruit juice concentrate and desire to market it to two strengths, namely $\frac{1}{8}$ full strength at 1/- per bottle profit and $\frac{3}{8}$ full strength at 2/- per bottle profit. If we had 1,800 bottles available for filling and despatch, we could fill them all with $\frac{1}{8}$ concentrate at 1/- per bottle and make 1,800/- profit. If we had 600 bottles available for packing, we could fill them all with $\frac{3}{8}$ concentrate and make 1,200/- profit.

Supposing that in fact we had 800 bottles available for filling and despatch, how could we best market the fruit juice? If they were filled with $\frac{3}{8}$ concentrate we should have 200 empty bottles on our hands (profit 1,200/-). If they were filled with $\frac{1}{8}$ concentrate we should be left with concentrate unfilled (profit 800/-).

A little arithmetical fiddling will soon show that if we filled 500 bottles with $\frac{3}{8}$ concentrate and 300 bottles with $\frac{1}{8}$ concentrate we should make a profit of 1,300/-, using up all the concentrate on the one hand and all the bottles on the other, and the profit would be a maximum.

It is not difficult to see that if the varieties marketed and the number of restrictions which curtailed one's ability to have it all one's own way were large, the complexities of arithmetical fiddling would pass over into the techniques of mathematicians. Linear programming is just that and no more.

I think it is interesting to have a look at some of the purely practical problems in which the method has been put to use.

Linear Programming of an airlift. The sort of considerations which apply are that aeroplanes must spend a certain time on scheduled maintenance in proportion to the time flown. Also that pilots can spend their time in three ways: flying, instructing, and resting, the rest period being either a constant or a function of the time spent in flying. Suppose that there is an indefinitely large reservoir of planes and uninstructed pilots to start with, together with a small nucleus of trained pilots. The problem is to minimise the cost of delivering a fixed quantity of goods by a certain date from the start of the airlift which is supposed to commence with the small supply of trained pilots, the cost of delivery and training of pilots being supposed known.

It is obvious that a situation of this kind must balance the training of pilots against the rate of delivery of goods. An over-production of trained pilots in the early stages of the lift leading to an accelerated rate of delivery of goods towards the end of the lift would be uneconomic.

So much is obvious. It is *not* obvious that Vajda's solution of this problem in a particular case leads to marked fluctuations in the delivery rate. If this is regarded as objectionable, then it is not obvious that imposing a subsidiary condition, namely that the rate of delivery in any one week should not fall below that of its predecessor, is not particularly costly.

Production of gramophone records. Vajda's airlift problem is very similar to one with which I was at one time concerned, and shows that these military problems have their industrial analogy. A recording on wax or plastic is converted into a master by electro-forming. If we regard the wax recording as a positive, the master is a negative. From the master a 'positive' can be made by electro-forming, being a metal replica of the original wax recording. From this positive, negative copy masters can be made from which in turn more positives can be made. In due course, positives can be used to make 'matrix' or stamper shells which are negatives, and these are used in the press-room for the manufacture of records which are positives and reproduce the original recording. A negative or positive used for making a positive or negative can be used to make another and another in succession at fixed intervals of time, but every immersion in the plating bath is a hazard which carries a certain probability of destroying the work. Similar hazards exist in the press-room. A stamper may be damaged by the press operator before it has pressed a single record!

The cost of each unit-operation is known. The problem is to minimise the cost of producing X records in Y days. It is obvious that by holding back the pressing operation, making no stampers and using positives to make copy masters, one can indulge in an exponential build-up of positives leading to a large production of stampers at the eleventh hour, and thereafter knock back the production order before the clock strikes twelve. Such a production pattern would represent an over-investment in tools. The problem is to minimise the cost of the operation, that is, to minimise the investment in tools.

At the time when these matters were my responsibility computers were not available for the solution of the problems involved. I wish they had

been because it would have solved a perennial controversy over costs. Owing to the well-known law of cussedness of inanimate objects, any important order requiring completion by a fixed time (to meet a closing date on an export shipment, for example) is abnormally subject to the hazards of the press-room and the plating bath! For this reason I was always anxious to maximise the chances of meeting the closing date by over-investing in tools, whereas my critics in the accounts department were equally anxious to minimise costs by under-investing in the same. An authoritative answer would have been a great help to both of us. The problem is difficult analytically even if one starts from a single wax recording. More usually, however, one starts from where the last order left off, that is to say, with a stock of partly worn stampers, positives and copy masters, together with a master which is regarded as precious and not to be processed save in an emergency.

The optimum use of these facilities makes the problem a very difficult one.

Composition of cattle food. A foodstuff consists of carbohydrates, fats and proteins, with or without vitamins, in proportions dictated by the nature of an agricultural or industrial operation. A diet consists of similar ingredients in proportions dictated by the nature of the animal which is to consume it. In particular proteins are compounds of amino-acids, some of which are essential and some inessential. The inessential ones can be synthesised by the animal itself provided it is fed with the essential ones. It uses these, however, less efficiently as a source of synthesis than as a food.

Subject to all the conditions which these considerations impose, it is required to minimise the cost of a diet consisting of a blend of foodstuffs each bearing a day to day market price.

Interconvertibility problems. Let us suppose that you have melted and cast an ingot. You can roll it yourself or sell it to someone else for rolling. Which? This sounds an easy question, perhaps less so if one remembers that a portion of the rolled product will go back to the melting shop as scrap. The question is only approximately easy when two stages are involved. When, as in the chemical industry, a mosaic of interconvertibilities are involved solving the problem can be very difficult. I well remember the difficulties I used to experience in trying to 'price' what we used to call 'process intermediates' when other manufacturers asked me to make them a quotation. Time often enters explicitly into the problem. Morton has given an example relating to the interconvertibility of timber and money in the following terms:

1. Money is convertible into money by investing it.
2. Timber is convertible into timber by leaving it to grow.
3. Money is convertible into timber by planting.
4. Timber is convertible into money by cutting.

Given a certain sum of money initially, how should a timber plantation be managed over the years so as to maximise the money equivalent at the end of a stated period?

The foregoing examples could scarcely resemble one another less: organising an airlift; manufacturing gramophone records; purchase and resale of cattle food; the management of a timber plantation. The feature common to them is simply that in each case we want to do whatever is involved as cheaply as possible, and that complexity prevents us from seeing the solution as obvious.

They are practical problems and should appeal to the practical man. But practical men will very often boggle at the solutions provided by the mathematicians. They may be the cheapest solutions, but from the practical point of view they are impossible ones.

I have already referred to one aspect of this. The situations described have hitherto defied rational analysis. Their management has therefore been the province of intuitionists endowed with an often high but non-verbal type of intelligence and a body of experience based on a standard practice which may be good, bad or indifferent; no one knows. We rely on some form of competition to ensure the survival of the fittest and are content that if two men run a race, the one that wins must be the faster. Faster yes, but, if both competitors are lame or hobbled, even the winner may not be fast!

Frequently the practical man who criticises the analyst's solution will draw attention to an aspect thereof which was never in the analyst's brief. Intuitionists are not good at writing briefs. They forget to include what to them is intuitively obvious. It may not be at all obvious to their analytical colleagues. And one aspect of such objections that cannot be obvious to the intuitionist himself is their cost. Until analysis has established the impractical optimum, no one can possibly know what could be saved by adopting it. Few things are more helpful to a management in orientating their organisation and methods programme, on the one hand, and their research programme, on the other, than an accurate assessment of the cost of submitting to some feature of their standard practice for lack of any known remedy.

The Theory of Queues

Mass production arose by breaking jobs down into simple repetitive operations each capable of being performed by an unskilled operative. Automation re-integrates them. Flow production is perhaps a better term. Any flow subject to local interruptions causes congestion, and the local appearance of a queue. Another name for a queue is 'stock'. A supply failure can be thought of as a negative queue. We must have stocks somewhere, but where? They are costly financially and occupy space locally, especially if they must be held adjacent to machines which technical considerations require to be as close to one another as possible for material handling purposes.

The formation and disappearance of queues requires to be studied as an advanced topic in the field of mathematical statistics. There is little hope of the non-mathematician ever comprehending its niceties. I want to emphasise again the problem of the unexpected solution, the solution not obvious in any intuitive sense.

A clinic involves a doctor who works continuously from 9.30 a.m., let us say, till 6.30 p.m. with one hour off for lunch. During the eight-hour period he will see 48 patients for an average consultancy period of 10 minutes each. The doctor must be kept busy at all costs in order to see the maximum number of patients. There must therefore be a queue of patients in order to ensure that he is never standing idle. His utility is jeopardised from two quite different directions. Firstly, the average of 10 minutes per patient is the mean of widely varying times. One patient requiring only a prescription or a National Health Certificate may be disposed of in a minute. Another with a complicated dressing to attend to may not be disposed of under half-an-hour. Secondly, not all patients arrive at the 10-minute intervals scheduled on their appointment cards. Some a rive early, some late, according to the punctuality of their dispositions and traffic queues delaying their arrival. Others arrive at random without an appointment and expect to be dealt with in turn.

It is not obvious that minimising the average length of the queue or mean waiting time per person is achieved by *starting with a small queue*. The first patient should arrive at 9.10 a.m., the second at 9.20 a.m. and the third together with the doctor at 9.30 a.m. according to a particular solution of the problem which takes account of real deviations from the scheduled arrival times and from the mean duration of consultancy periods.

Now there is an interesting feature of this problem from the standpoint of practicality. It depends upon the co-operation of the public, assuming the secret gets out. The public are in fact asked to make an act of faith in a procedure which they can never hope to understand and which must appear cock-eyed to the superficial critic. "Ten past nine ?" you can hear the cynical patient remarking, "Not me! The doctor never gets there till 9.30 and he's always got two others waiting by then."

Why not bring all three patients in at 9.30? Well, what happens if they are all caught in the same traffic jam? These solutions are statistical solutions. They minimise the total waiting time, taking one day with another, and averaging it over a long period and they *include* the variations of the early patients as well as the later ones.

Suppose now that a 'practical man' asserts that the public will not co-operate; that they will waste their own time and the doctor's by sabotage of the scheme based on ignorance of its rationale. He may be right, but the analyst can give him a valuable piece of information by way of rejoinder: what sabotage will cost in wasted time as compared with co-operation. And that will determine what it would be worth while to pay by way of a public education campaign. I mention this to reinforce what I have said earlier about the cut and thrust between intuitionist and rationalist. Even if the analyst's optimum is impractical it forces on the intuitionist an awareness of what practical limitations cost. This could be forced on him in no other way.

Need I add more than that a continuous transfer-line must obviously be subject to local queues if the whole line is not to halt when any part of it halts? The optimum points for holding a buffer stock require analysis in terms of queue theory. Nothing but good can come of such analysis.

Real-time management

Few things are so useful as a good nomenclature. The various branches of science are quite unscrupulous in borrowing useful terms coined by their neighbours. Consider, for example, how acoustics has benefited by borrowing such terms as capacitance and impedance from electrical engineering. I think management and administration can with profit do likewise and I propose to borrow the concept of 'real-time working' from guided missile research.

Assuming that one can locate and track an aeroplane in flight, it requires but little ingenuity to plot a graph of its trajectory. From this graph one can calculate exactly what track a guided missile should pursue in order to home on the objective, together with all the movements which its control surfaces must make in order that it should follow the indicated path.

This sort of exercise can keep a mathematician busy for weeks, and, if one regards full employment for mathematicians as socially desirable, one must concede its merits. It is of little use, however, to Fighter Command. To be of practical use the calculation must move as fast as the object to be attacked and directions must be complete and ready for dispatch to control surfaces in time for them to be effective. This defines an operation in real-time.

For 'mathematician' read 'accountant or works planner'. If you think it desirable for companies to comply with the Companies Act, then you must concede some merit to any balance sheet filed at Somerset House within the statutory period. If this means six months or a year after it could serve any other useful purpose, then its preparation is not an operation in real-time.

Works planning must proceed in real-time and here the computer may be the key to the future. An interesting account was recently published in the "*New Scientist*" of a domestic operation which you have evaded by coming to this Conference — washing up. I reproduce opposite the conclusions of the author (Figs. 1 and 2) with the caveat that if only three plates, one knife, one fork and one spoon were involved, a single operator could finish them all in the time that one pencil and paper planner could work out a schedule of operations for three persons with division of labour. Paper and pencil planning of this kind cannot work in real-time and therefore cannot justify its cost. Assuming a computer to be available, however, the situation is otherwise and planning, of an

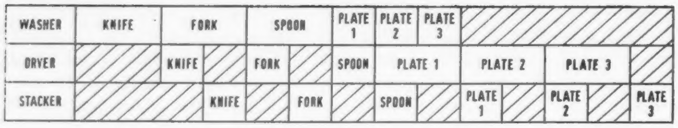

FIGURE 1

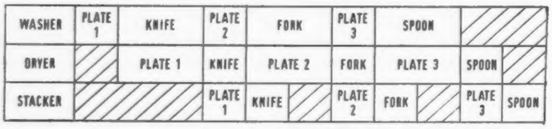

FIGURE 2

Courtesy of " The New Scientist ".

In an article published recently in " The New Scientist ", the author uses these illustrations to illustrate how idle time can arise in washing-up. The widths of the rectangles represent the times required for each operation, and the shaded portions represent idle time (Fig. 1). The author points out that the efficiency of the process could be greatly improved if the washer started his job in a different order (Fig. 2).

order of complexity quite beyond our current powers, is made possible.

Machine shop loading tends to be in the hands of the shop foreman who works on an intuitive basis because the problem is beyond anyone else. He is an excellent man in most cases. However much one tries to make him work to a master plan, he knows that fate and the Inspection Department cannot be coped with in real-time by anyone but himself. Challenged to do his work better than he can, most critics would hum and haw before slinking away. I am continually reminded in this context of the lame man who can win a race against other lame men. Shop loading is a job at which none of us is any good and the fact that the foreman can do it better than his critics is no answer to that basic situation.

Flow production scheduling is another such situation. Henry Ford said that his cusomers could have a car of any colour they pleased, provided it was black. Production scheduling is the engineer's answer to Henry Ford. It makes it possible to give customers limited freedom of selection between different colour schemes and optional extras, the combinations of which are too numerous to permit of stocking. The customer now gets the benefit of both worlds: that of the mass produced and the custom built article. Think of the data processing involved in this. It must all proceed in real-time and will get more, not less, complicated with the years.

Stock control must be an integral part of the factory system. Machine shop loading and production scheduling must perforce be linked to the stock position. If we use a computer for any one of them, it will be only natural to use it for the others. We often hear of computer installations first in the context of wages and P.A.Y.E. I believe wage calculation to be a more difficult and less profitable task for a computer than stock control. The real-time element is more exacting; payment of wages on the dot has to meet social as well as technical criteria. Moreover wage calculations are already highly mechanised, whereas stock control by machines is relatively unexploited. It is the linking of wages to co t accountancy that seems more likely to exploit computer potentialities to the full. If one postulates a computer-centred system integrating stock control, production scheduling, machine loading, cost accountancy and wages, and operating in real-time, one begins to get a picture of what future administration may be like.

Management by exception. A feature of managerial data presentation as carried out at present often consists of five columns of figures. This month's, last month's, this-month-last-year's cumulative to this month, and cumulative to this-month-last-year. An important person in the management hierarchy is the individual who can:

(a) assimilate the schedule without going dizzy;

(b) pick a figure at random and say (rightly) 'I bet that's wrong';

(c) get something done about any performance which compares unfavourably with last month's or this-month-last-year's.

Under criterion (a) there are not enough people who could do the job properly to do it properly, and the five column procedure is a quite unscientific approach to its solution. One needs the standard deviation item by item for assessment purposes and a criterion of significance, .05, .01, .001 . . . etc. precedent to enquiry. Any secular increase in the mean also needs watching.

The discriminatory power of a computer should enable all such items to be picked out and presented in the form most suitable for initiating action. Nothing else needs presentation.

Secular increases, for instance, could be shown as presumptive annual totals and printed out in order of descending magnitude. I want to see just this information and no more available in real-time as a constant reminder to take action. I want to be informed prospectively once a day, a week, a month; not nagged at retrospectively once a year.

Social consequences

You will find an excellent essay on industrial mathematics in the May issue of our Journal. I have been taken to task elsewhere for talking "sheer mumbo-jumbo and balderdash" on this subject. For this reason I have endeavoured to make my illustrations as concrete as possible: airlifts, gramophone records, cattle food, forestry, clinics, machine shop loading, production scheduling, stock control, costing and management accountancy. If anyone thinks these subjects abstract or unimportant he is free to do so. I have said nothing of Games Theory or some other branches of the subject, preferring concrete illustrations of the part to duplicating a general exposition, already available in our Journal, of the whole.

In conclusion I would like to draw attention to the indirect, as opposed to the direct, consequences of what is being developed. I don't mean unemployment among accountants. I have discussed and dismissed this imaginary danger elsewhere. I want to say a few words about the tone of two kinds of society — one in which decisions drag on and the other in which they are made resolutely and quickly.

Psychologists have established that anxiety, suspicion, aggression and a sense of guilt or failure form a closely connected set of symptoms such that if one is called into being, the others come into existence alongside it.

There are various theories as to why this should be so, but no one appears to doubt the fact. If a decision isn't taken quickly and resolutely one begins to distrust one's colleagues, to doubt what they are playing at, to question their integrity, to become difficult and unco-operative oneself and, finally, to collapse into a sense of failure partly real because one is beginning to contribute to it.

Modern management techniques could be *foci* for a new spirit in the community by enabling decisions to be made quickly, because rationally, and on sufficient information. We need this boosting of self confidence in a community divided against itself. The language and course of many wage negotiations, for instance, seems increasingly out of keeping with the techniques available for resolving them. This year's pay rise is being tabled while last year's is still being settled. That is scarcely operating in real-time, is it?

Consider negotiations in respect of which we inherit a dilapidated set of attitudes which came out of the Ark and now need streamlining; a new look, as it were. In too many cases bazaargaining is accompanied by attitudes expressed in the classical lines,

> "Sam stuck his tongue out at Noah
> And Noah made long-bacon at Sam."

Maximising wages distributable over a period ought to be a straightforward calculation in econometrics. The sole and only object of net capital formation is to produce more goods for the consumer. But capital formation reduces the consumer goods available. The problem is of the dynamic interconvertibility type which I have discussed under linear programming. It ought not to be insoluble.

It would be premature to sell these ideas to either side of the bazaargaining table as yet. The most we can do is to set the rest of the community a good example by exploiting new techniques of management as hard as we can in the belief that they will spread, as spread they will, for rationality like appetite grows by what it feeds on. We must not expect too much too soon. Operational research is but 15 years old, computers but 10, and their industrial use but five. We are only at the beginning of things and have as yet more to learn than to teach. As yet.

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said, on which he might be allowed to quote one of his favourite passages from the Old Testament, which enjoined modesty on everyone: "Let not him that putteth his armour on boast himself as he that taketh it off". If, when his time came to invest his successor, half as many kind things were said about his incumbency of the office which Mr. Hancock had just vacated, he would have occupied it not unworthily.

He must not, however, expand on that theme, or he would be anticipating what their mutual friend the Chairman of Council would be saying, more felicitously than he could, on a later occasion. He would like, however, to thank Mr. Hancock for all the work that he had done on behalf of the Institution, and with those thanks another Past President of the Institution, Lord Sempill, had asked to be associated.

Lord Halsbury then delivered an address on "The Administration of Modern Production", which appears on page 480.

THE EFFECT OF AUTOMATION ON MANAGEMENT ORGANISATIONAL PRINCIPLES AND PRACTICES

by Dr. LILLIAN GILBRETH.

A verbatim report of the address given at Harrogate.

IT is a very great pleasure for me to be here with you today. I have to thank you for a very cordial welcome. When I arrived yesterday I found busy people interrupting their schedules to come down and make me welcome, and lovely flowers in my room. I was able to have dinner with your Executive, and I have had the pleasure of shaking hands with so many of you that this morning I do not feel that I am speaking to a group of strangers, but to a group of friends. I thank you also for my country, for inviting one of us to come and take part in your programme.

I have three resources for what I have to say. The Chairman has already mentioned the Management Congress in Paris. It was the 11th Congress which we have held, the first taking place in 1924 in Prague, when Czechoslovakia was still a republic and had the courage to invite management people from all over the world to come and discuss management problems. At the Paris Congress 27 countries were represented. I shall not attempt to tell you much about what was said, in the first place because too much was said for me even to attempt to summarise it ; one needs to get away and think about it and let the significant things emerge. Secondly, there was British representation and the Papers will be available here.

The second resource is the fact that one of my former students for a short time in the United States, whom I may call a member of my family, as she lived with us while studying, and since, is Miss Anne Shaw, one of your consultants, whom many of you know well, and who would have been here had she not had other responsibilities.

The third resource is what we are doing in the United States of America. I am entirely conscious of the fact that what one organisation in one country tries to do has first-hand value only in that country. All that one can ask of you is to evaluate what is said, if you are interested, and talk it over when you have time and see fit to do so and, if there is anything in it which seems useful, tentatively try it out. We are not apt to find people in your group coming to our country in the spirit in which so many people do visit us, looking for answers to questions when we are not sure what the answers are, or even what the right questions are, and they are not sure either. It is in a tentative sense, therefore, that I take up my subject.

This new challenge

What are we going to do, faced with this new challenge of automation, about evaluating what has already been done in the management field ? I think that we feel in the United States, and felt even more at the end of the Congress, that evaluating what we have done to see how clearly we really knew the problems which we were facing was our first job. That ought, I know, to be a continuous job for every one of us ; but in the press of everyday life, and because we are in the middle of these problems, we do not always have time to evaluate.

We feel, however, that any post-war period, whether automation is an issue or not, is an appropriate time to evaluate what has been done. During the War, I am sure that here as elsewhere fundamental adjustments were made to try to meet war needs. With us, Government took over much that it had not taken over before in relation to private industry. I worked for much of the time in a small plant making instruments of precision for the Navy. It had been a small plant, but it needed to expand. It needed money and it needed personnel,

and it had to take on for the first time a large group of women workers where there had been no women workers before. Even that was not enough, but we were an essential industry and the Government helped, getting us buildings and machines and almost everything else that we needed.

When the War was over, the industry had this expanded personnel and these expanded responsibilities and, of course, almost everything had to come back on the organisation itself. It required a strict evaluation to find out what we were going to do and why we were going to do it and the way in which it was going to be done. Our little industry was, I think, a pattern of what happened all over the country. Evaluation, therefore, comes first with us.

Importance of terminology

This immediately leads us to the need to re-value and re-define all our terminology. I could not help feeling, during the time that I have been in Europe, and particularly during the Congress, that many of our troubles come from not understanding one another's vocabulary, and sometimes from not understanding our own. That is a problem, I think, which arises between you in this country and us in the United States. We both use the English language and our problems seem to be much the same. And so, stupid though it may seem to people who are eager to plunge into what they think is the heart of the matter, we feel that every time we start a discussion an agreed definition of terms is necessary. Often that definition proves to be the heart of the problem, because when we define our terms and agree on what they mean the problems present themselves in very different ways.

We have had great help in that respect from a small and very tentative Dictionary of Management Terms which was issued by the American Society of Mechanical Engineers through the activities of its Management Division. Those of you who are interested in the history of the development of scientific management will know that all our pioneers, or almost all of them, in the United States not only were mechanical engineers, but worked in the industrial field in which mechanical engineering participates. The Management Division, the largest Division of the Society, is very active through its committees and sub-committees. It has issued this little Dictionary, of only a few pages, which you can obtain by writing to the American Society of Mechanical Engineers. I am sure that probably many of your professional bodies have copies.

Fortunately for us, it is also part of one of the two industrial engineering handbooks which have come out during the last year or two. I mention those only because they give far more accurately, and with illustrations and details, all the material to which I shall refer today, and much more. Each is a collection of Papers written specially for it by people who are authorities in this field. The first was published in 1955 and is called "A Handbook of Industrial Engineering". It was edited by two professors at Stanford University. Most of our professors in these days also do industrial work, so that the editors had more to contribute than simply editorial functions ; they had the kind of background and knowledge which enabled them to select good people and to see that the contributions were what they should be. The two professors are in the Graduate School of Business at Stanford University in California, and the handbook is published by Prentice Ford.

A little later the second one appeared, called "Industrial Engineering Handbook", containing the same sort of material but with a slightly different emphasis. I think an objective reading of the two would show that some of the techniques are better presented in one and some in the other. This second handbook is edited by H. B. Maynard, one of our outstanding consultants and a member of the American Society of Mechanical Engineers, and is published by McGraw. In this handbook, immediately after the introductory Paper on Administration and Organisation, comes this Dictionary of Terms. It is very fortunate that we have it to refer to constantly, because it is quite a job to read through the book from cover to cover, and it saves a great deal of time in getting down to the fundamental things that the writers present.

Looking at the title of our topic this morning, *automation* is an important word which needs definition, but so also do *administration* and *organisation* and *management*, words which we know very well and probably think we could define very easily, but which it is not so easy to define when you take a pencil in your hand and somebody asks you for definitions. The definition in the Handbook is that *administration* has to do with planning of the project, the final field of responsibility, the policies and so on, and then we come to *organisation*, which tells us who is to do it and defines the functions, and then, of course, *management* derives from there. Even in my Company we do not all agree on the definitions of *administration* and *organisation* and on the relationship of the one to the other, but we feel that it is essential to work these things out if we are to do any kind of evaluation, so that we can exchange experiences and not find in the middle of it that we are grouping our experience under different headings.

The key word

Automation seems to be the key word in every discussion today. I well remember the first time I heard it. It was in the report of a speech by John Bedaux, whom we still look on as our leader in this field — young, enthusiastic, studious, devoted. He gave a key Paper in this field at the Congress in Paris, a very human and a very fine presentation. The first use of the word in the United States was very much tied up with "automaton". It seemed to mean merely using the resources of nature as far as we possibly could. Naturally all of us in the engineering, production and scientific fields, as all of you are, found our code of great help here, and our code refers to using the resources of nature and of

human nature for the benefit of mankind. When, therefore, the idea got about that automation had only to do with machines and the use of different kinds of power, and that, to use the popular concept, it was just another one of those technical things which engineers were bringing in and which was going to do away with all creative activity, and so on, it was a tremendous help to us to be able to say " Here is our code, and this is what we stand for ".

Even if people insist on defining automation as having to do only with the resources of nature, you can rest assured that we, who are obligated to use these for the benefit of mankind, will act in such a way that it will be safe in our hands ; but it seems to us that it would be wise to include as soon as possible the human factor in the definition of automation. Everybody seems to have a feeling that we can have nothing to do with the definition of terms so far as the every-day dictionary is concerned, but that is not true. The dictionary only records correct practice as it grows. If we all begin this correct practice of insisting that automation does include the human being, we shall get that definition into the next dictionary, or the one after that. Over and over again I have been able to convince people that, rightly handled, this can be a constructive thing.

The questioning method

In addition to our code of ethics, the second thing that we have to offer is that we believe in the questioning method, the scientific method. We also believe in freedom of speech and thought, and we ask and do our best to answer questions, no matter who puts them or how they are put. It is not the Socratic type of question, where one shows that the person who puts it is not very bright, and it is not the legal type of question ; it is straight intellectual curiosity, which leads someone to ask " What is this ? " ; " Why is this so ? " ; and so on. No doubt you remember the little rhyme :

" I keep six honest serving men,
They taught me all I knew ;
Their names are What and Why and When
And How and Where and Who."

Those are our tools in evaluation.

I think that for some time we may have felt that *How* was the most important, and *How* is indeed important. Having worked for most of my life in a *How* area, on the methods by which work was done, I still feel that it is very important, but more and more we are beginning to say *Why*, especially with the great emphasis which is being placed on the social sciences — psychology, psychiatry, sociology and all the rest. It is in that area that the development has come ; and, as we continue to put emphasis on the human side, we go into *Why* as thoroughly and as deeply as we possibly can.

In our everyday evaluation of what we are doing in our own plants and in our own production problems, we are faced with this question of *Why*. We found with us a great many organisations that had their *What* fairly well established, but deviated for one reason or another during the War. Some of them packed up what they were doing and took over something more vital for the War effort, and after the War took what they had been doing out of the moth balls and went on again from the point where they had left off, having adjusted such things as personnel problems, salaries, wages, labour conditions and so on ; they did not have the great problem of what was to be made. Others had to start on something new. The analysis of *What* — not only what should be the main thing produced, but what was to be the part of each of the functions involved — has been one of our problems. The *Why* questions do not arise only at the beginning ; having talked about *What*, we are faced with *Why* such-and-such a thing has to be done, and we have to justify what is being done in each case by answering the *Why* as well as the *What*.

Then comes the question of *Who*, and here again an enormous amount of adjustment is being done. In our experience during the War years we had many young men eager and willing to go into the Services and some, perhaps, not so eager and willing, but all wondering when they would have to go and waiting for the time to come. They were all absolutely useless to themselves or to anyone else so far as any systematic schooling was concerned, and in many cases the Labour Laws were temporarily set aside so that we could bring them in and make them feel that they were needed and necessary by giving them some activity. Women got many jobs that they had never done before, and retired people were called in. Our experience there was so successful that I cannot understand why we have gone back to the retiring age, unless it is that we have not really thought through that problem adequately. There was also the enormous success which you had, and which we had too, in bringing in people who were physically disabled in some way.

A great deal has happened in the *Who* field since those years. I know of the fine work which has been done here, not only in your Government activities of all kinds but in your industries, in working out psychological tests and interviews and other techniques which have to do with personnel relations. I sometimes think that we forget how much technical material we have in the human relations field, just as I think that we sometimes forget how much personnel relations we have in the so-called technical field. We people whose prime responsibility, after all, seems to be to get the work done are in fact the primary people in the field of human relations so far as the worker is concerned.

We did an experiment by taking away from our foremen and superintendents a great deal of their human relations activities during the War. We put in special people to deal with human relations, and we said to our foremen and superintendents : " You get on with the work and these people will handle the workers ". It was not successful. At the end of the War, when a survey was made to find out what the foremen and superintendents felt, they said : "We want our human relations projects back again ". That sort of thing comes in the domain of the *Who*.

Like you, we are developing psychological tests, but we do not find that they are so adequate that we can even think of doing away with the interview and the personal contacts, and especially with the practice of letting the worker see where he is to work and the people with whom he will work and letting him talk to the people who will supervise, and so all down the line. We know very well that warm, heartfelt human relations are so important that often we say that they are the most important thing of all, and that if we have good human relations that is all we need, and that all we need for good human relations are warm, friendly hearts ; but the technical people have a point when they say : " We want and expect that, but it will not completely take the place of technical adequacy on the job."

This concerns not only you and me, who happen to be out in the factory concerning ourselves with the product as it comes off the line, the quantity and quality, but also the people who deal with personnel problems, educational plans, training plans and so on. We differentiate between training and education, defining training as what a person needs for his job or the job ahead, which can appropriately, we think, be given by the person to whom he looks for supervision and advice, so that there is more and more teaching of foremen and supervisors and all the way up to top management itself, as it is realised that training is a part of everybody's life. Education, on the other hand, not only makes us better and more all-round on the job, but more all-round in regard to life itself.

Methods work

We then come to the work being done in the *How* field, the methods work. Considerable ramifications have grown up over the years in this field. With us, as you know, the pioneer work in time study and motion study has developed into what is called work simplification and directed energy, and then the added structures of M.T.M. and so on. All this has to be carefully evaluated. You will be interested to know that probably Australia will have the pioneer project of evaluating everything in this field, taking the pioneer work and the way in which it has been carried through and the modifications involved in the new fringe activities which have been added and trying to find out whether we can develop something which we can all accept as fundamental enough, so that instead of splintering more and more and deviating more and more, we shall gradually get a larger amount of common knowledge and experimental data.

Far be it from me to stop anybody, any individual or group, from modifying and trying to improve on or add to what has been done by the pioneers and since then. I think it is unfair to infer that if the pioneers were here today, they would do things exactly as they did then. I am sure that that is not true. They would have faced the problems of today. I believe that if what needs to be done is to discard what used to be done we should do so, and I believe that the pioneers would approve it, as their lives show ; but we must be sure that we are not (as my husband used to say) " inventing downwards ", so that the new thing is not as good as the old. We have to show that at least we know what was done and the lines on which development has taken place, and we must try to build on to what has been done.

A widening field

Another thing which has come out very strongly in this methods work recently is the fact that not only methods work, but all the management principles and practices which we are trying to evaluate today, apply to every kind of activity. There was no difficulty, of course, in understanding that after a start had been made in the factories and on industrial work there would be an extension to office work. Even in the days of the pioneers there were people who began to specialise in this field. From there we have seen an expansion into every branch of business. This expansion has been of great importance and interest to us, and now we have reached a point where management in hospitals, in libraries, in local, regional, State and national Government, and so on, can make use of these things ; all the things which we have learnt can, properly used by instructed people, be employed in these fields. It is especially gratifying to see the work which has been done with physically handicapped people of all kinds, and not war casualties only.

It is not only a question of training people for jobs; it has now been recognised that the housewife and the home-maker have real work to do and that there is a real reason for every sort of management material being given to them. If there is one phrase which is annoying to hear it is : " I'm only a housewife ", because it seems to me that this is not only one of the most important but one of the most stimulating and worthwhile jobs in the world. Studies are being made of the young housewife who has had an accident or has a heart condition, or who has had tuberculosis, or is a polio victim, and we find that, through management and methods work, we can design equipment and all that sort of thing, with the co-operation of the doctor, the nurse, the therapist, the engineer and indusry. After all, there is a large market in the home. Having made a beginning, we are able gradually to bring in the other principles of management which make life easier and smoother.

This sort of thing is being reviewed in other countries, and it is interesting to find that very often the studies which seem rather on the fringe to us — and I should add agriculture to the number — are the things which to them lead to the first approach. I have had the opportunity to visit the Philippines, Formosa and India and to spend several weeks in Australia and to visit other countries. It was really in the field of the villages, the small activities, so to speak, that this was most interesting. I wish that I could hear your discussion on small industries, because with us we feel that the small industry has been neglected. I count the household and many small farms and hospitals and so on as in that category.

It is very interesting to see that in the so-called under-developed countries the work done in some of these fringe areas is so impressive, because they do not have the big factories and the business projects which we have, and when they send their students, as I feel that they sometimes do in almost too large numbers, to you and to us, very often I think that they go back discouraged, because the enormous organisations which they see make them feel inferior and subdued, as became very evident at the Congress.

Sometimes we find that some fine agriculturist or home economist has gone to one of these countries, and sometimes they do the best work, because they go right into the homes of the people. That kind of experience makes us realise that we have to simplify all our thinking. The agriculturist finds that these people are cutting their grass or rice with a wooden scythe, and he gets them metal ones and then finds that they will not use them, because they have a brother-in-law who has made his living for many years by repairing the wooden ones. There is a whole pattern to be thought through.

There is an economist who goes all over the Philippines and buys lovely native hand-work and takes it to the New York market. The buyers say to her : " Your merchandise is fine. We will take 250,000 of these ; when can we have them ? ". To make 250,000 would take heaven knows how many years. The buyers say they can give her three months, and perhaps six, but no more. They explain : " We cannot go beyond that, because the American market is so fickle. These things would fit in with today's fashions very nicely, but we have no idea what the market will be like a year from now ".

The need for simplification

One man got up after John Bedaux's talk on automation and said: "This has been most interesting, but it looks so difficult for us. It will take us many years to go through all the things that you have gone through ". Mr. Bedaux replied : " Perhaps you will not have to do any of that. You may be able to take a short cut, because we are now in a stage of simplification, and if we can make things simple enough it will be possible to avoid all these intermediate steps." I thought of that as I listened to the most interesting and humourous address of your President this morning. I thought to myself how simple it really is to calculate things ; such examples and such procedures it is easy for people to follow. I think that that is an implication in your work and mine ; we have to look at these new things and see how we can simplify them. That day may come. Especially do we need it in the United States, because, as you know, we love a new thing. That is often one of our difficulties, and top management and middle management are as much to blame as anybody else in this respect. The President of some business goes to his club, and the man next to him says " Are you using operational research ? " — or linear programming or depth interviewing, or whatever it may be. The President replies : " Why, of course, we are; we're right out in front of the industry ". Then he goes back after lunch and rings every button on his desk and brings everybody in, and he says : " I have had a very embarrassing experience ! ".

Delegation of responsibility

That brings up the question of delegation of responsibility. In our revaluation, we have come across a tremendous amount of material on delegation of responsibility. I was very interested when in Paris to find that there seemed to be no good translation of " delegation of responsibility " into other languages. A very up-and-coming young stalwart is writing a Paper now on different English phrases — " phrases in English " would perhaps be more accurate — which are always used in English in other languages, and nowhere has he seen " delegation of responsibility " in any language but English, no matter what the language of the rest of the article may be.

Just as we have come to stand for that phrase, I wish that I could report that in the thing itself we were doing an adequate job. In the first place, it seems to me that very often people do not realise what responsibilty they have. For example, a Congress or two back a project was suggested of trying to find out what top management actually did with its time, and Sweden, being up-and-coming, said : " We will investigate ". A university professor, with an industrialist and an agriculturist to help, made up a questionnaire, and selected students who were physically fit and mentally and socially suitable and sartorially smart, but he did not give them a final briefing, and they came back and reported that the top executives did not choose to say what they did with their time. The professor said : " I neglected to tell you that you should start by saying that you knew that there were a good many things being done which would not show themselves in any outward activity at all, and that even if the top executive were out three hours for lunch or sat with his eyes closed after lunch, that was no indication that serious planning and judgment and so on were not going on ". I do not know whether the second lot of students succeeded any better than the first, but I am sure that we are not going to solve delegation of responsibility until people know what their responsibilities are.

No one can expect any individual, including a top executive, to have all the qualifications to meet all the responsibilities which management, administration, organisation and so on put on him. I have a friend who was selected as Vice-President of a large organisation because the head of the organisation seemed to have everything in the world except a knowledge of how to get on with people. He understood money, he understood planning, he understood marketing and he understood production, but he was not good at getting on with people. My friend is now President of the company, and he has to offer a wonderful understanding of human beings, but he will have to surround himself with people who will share the responsibility in their fields.

That is not so important as the fact that many people do not realise that when they delegate responsibility, that is not the end of their job. I do not know what you do with the time and energy that you save by delegation; nobody has ever confided that to me ; but you and I know that, when you delegate responsibility, the final responsibility stays with you, and if a thing is not done you cannot say : "I delegated it. I'm sorry if it hasn't been done". You have to say : " O.K. I didn't follow through on it, and I take the blame ", and then go away and try to find out what happened. That is one of the things, I think, which is going to come right to the front in this automation problem.

I want to say a few words about the various changes in the automation field that are coming to us. It seems to me that you and I for the moment should consider that we are the public, or that we are the human element, and we are asking the top flight people in automation certain questions, such as what are you going to do for us ? What do you expect of us ? What is the future going to be ? If these people are purely technical and have not given much thought to the human element — and there are some like that — we shall not get many answers to the questions that I am going to ask. If they are concerned wholly with the human element, we may get answers weighted on that side rather than the other.

What is drudgery ?

The first question we would ask is, what do you expect to give us ? Nine times out of 10 I have found that it is that we can do away with drudgery. Well, who does not feel that it would be a wonderful thing if we could do away with drudgery ? There is just one small question involved in that : what is drudgery ? Is it the same thing for everyone ? I suppose we all know what it is : it is heavy work, tiring work, work which most people would not find creative or interesting. I do not see how anybody can object to this going. When I think of my grandmother's kitchen and my mother's kitchen and my kitchen and my daughter's kitchen and my granddaughter's kitchen, and the amount of time and energy involved in doing things in them, I am glad to see that happen. I remember our going on trips in the early days, and the size and weight of the luggage and the hefty man who carried it down and the horses that took it to the station, and now when I go to the airport I see the sort of luggage that people take with them nowadays. I see materials handling exhibitions full of devices for doing away with drudgery, and it seems wonderful.

But that kind of thing is not drudgery to everybody ; definitely not. I have a friend who says that she would rather scrub the kitchen floor on her hands and knees than use equipment which she does not want. She likes doing things herself. I said to her : " You are nostalgic, looking to the past instead of to the future. Wouldn't you rather take exercise by walking and seeing how beautiful the world is than by scrubbing floors and working at the washtub ? ". She says " No ", but I still think " Yes ".

A word about repetitive work. That is drudgery to a great many people, but not to everybody. Some people like repetitive work. I remember one girl at a factory who for six days a week put in four screws all day long, 1-2-3-4, 1-2-3-4. I came in one morning and found her crying, and I asked her what was the matter. She said : " We have a new thing to make, and I hate it ". I asked her what she had to do, and she replied : " I have to put in three screws instead of four, and I don't like it ". I asked her why and she did not know. She began crying worse than ever, and I did not know what to do, but finally I said : "What do you think about as you work all day long ? ". Before that she asked me who had changed the number, and I said " Probably the salesman " — I am a production person, so it is always the salesman ! When I asked her what she thought about, she replied : " I love dancing, and I just go 1-2-3-4 and I two-step all day ". Then I knew the answer, and I said : " Mary, do you like to waltz ? ". She did, and now she waltzes happily all day, 1-2-3, 1-2-3. There is a pleasurable sensation associated with it.

It would be hard to have to tell people that we no longer need their services because of automation, but people retire and resign, and we should be able to make changes without putting anyone out of work and without having to go through the procedure of consulting the shop steward and everyone concerned, which is right and should be done. There is an Australian author who has written a wonderful work on " The Challenge of Today ", and who came to the Congress and said that it is marketing which you and I, who have been in production, must think about. It is going to be expensive to do these things, and we must try to keep the machines at work. We have to keep our eyes fixed on the market, or we shall have something like the position with the old rice machine in the fairy tale, with the rice mounting up and up and we not able to get rid of it.

There are long-term and short-term views on this. The automation people have a point which we must think about. They say : " We shall need more skilled people and fewer unskilled people ". That is a problem which we have to face. They say : " It will mean a shorter working day and a shorter working week ". The key word there is " work ". They are talking not about days and weeks, but about work. It is fair to ask what the *actual* working week is. There are rumours in the United States that the office working day is not what it appears to be from the records, when account is taken of the coffee break in the morning and another break in the afternoon. There are advertisements in our restaurants saying : " We will feed you in five minutes, leaving you 55 to go shopping ". You cannot eat enough in five minutes to carry you through, and so there has to be a coffee or tea break in the afternoon. When we come to consider how many minutes and

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PRODUCT DESIGN FOR AUTOMATED PRODUCTION

by D. L. JOHNSTON, B.Sc.(Eng.), A.M.I.E.E., M.S.I.A.

Mr. Johnston was in the design team responsible for launching the post-war range of Marconi Instruments Ltd., before joining Elliott Brothers (London) Ltd., in 1946. There he worked on the engineering of industrial and service control equipment, including the initial stages of the TRIDAC analogue computer and the series of digital computers.

In 1953, he moved to Fortiphone Ltd., to work on sub-miniature transistorised equipment, and in 1956 he joined Automation Consultants and Associates Ltd.

THE rate at which productivity and the standard of living can advance nationally and internationally depends greatly upon what production engineers can achieve and how quickly the "know-how" from research and development is applied to production processes.

The many discourses of recent years have produced a vast amount of new knowledge which is now available to those who seek. The present Conference provides a means of satisfying the seekers and is a logical extension to "Margate, 1955", when automation was well and truly launched as an exciting new opportunity for all.

Some of the economic, social and technical problems of automation have received much attention and are now better understood. What we have not yet discussed adequately enough is the impact of automation on the design of products, rather than the actual usage and effect of automated plant.

In product design much greater use should be made of "simplification, specialisation and standardisation" internationally, together with a modular approach to the sub-division of machines and structures. This economises in design effort, as well as in cost of production and distribution.

Under-developed countries can advance very rapidly by drawing selectively upon the experience of the more advanced countries, whereby they can enjoy a foresight of what will be available to them in the future. Thus they can "leap-frog" some of our pioneer mistakes, and select advanced and economical basic product-designs adequate for their requirements. Such designs have a long life before they become obsolete in such usage.

Dynamic or static economy?

Less than 20 years ago, both our national and our technical press wrote against the establishment of factories for consumer goods in Australia and India, as a blow to our export trade.

Today it is better appreciated that the under-developed territories represent a potential market several times as great as our own, and that what we have to export tends to be the means and knowledge of production and design, rather than the material and labour content of the products, for these are generally available more cheaply locally.

The situation is now seen as a dynamic one, in which three main phenomena occur:

(a) In the Western world there is a steady annual rate of increase of real income.
(b) This is partly due to increased productivity through detailed evolutionary improvements, and in part to revolutionary advances such as the development of electrical communications, air transport and atomic energy.
(c) In less advanced territories, numerically several times our Western population, the same developments appear, but on a retarded time scale. Thus "backward" countries are not fundamentally inferior in their social and technological structure, but merely exhibit an historical displacement which may catch up very rapidly.

An important corollary is that "backward" countries thus have access to a "crystal ball", and can foresee their own future trends and leap-frog over some of the mistakes and difficulties of the pioneer countries. Dr. Margaret Mead showed in her recent book how a tribe in New Guinea bridged 1,000 years in one generation. With wise leadership very rapid advances are possible in such territories, especially if local mineral resources can be developed to pay for capital goods.

The politician and statesman is traditionally a student of history and an exponent of the static society. International statesmanship since the War has begun to appreciate the dynamic characteristics of world development, primarily, perhaps, as a result of scientific appraisal of world food and fuel requirements and resources.

Organised labour has also accepted the fact of continual technological change, more readily in the U.S.A. than here: if our labour relations were relatively more enlightened prewar, the U.S.A. has started from the atmosphere of the Detroit riots of the 1930's, and today can digest the problems of automation more rapidly than we can.

Amongst these trends, the scientist and economist can predict "*where*", that is, the direction that developments will take: but for the important question of "*when*", the statesman must turn to the production engineer, who alone can set the pace at which they are translated into quantity production at economic cost.

Design and productivity

It is remarkable that Babbage, who pioneered the ideas of the programmed computer, was able to write 125 years ago—

> "repetitive, routine human action should be done by machinery, and goods should be designed so that they can be mechanically manufactured".

Norbert Weiner stressed, much more recently, that it is degrading to use human beings for manual tasks far below their mental capacities, and much attention is now being given to the economic and social adjustment of industrial society to automation (Report of Director—General, I.L.O., 1957).

Much less has been done to pursue the second part of Babbage's statement, the subject of product design for automation. In fact, most examples of automation relate to products as originally designed for batch production.

Future advances in productivity in industry as a whole may well depend as much on a new approach to design and distribution of the product, as on improvements in the manufacturing process.

When the late Dr. L. Rostas published his classic study of productivity in 1948, he stated—

> "by far the most important way of increasing the standard of living of the population is to increase the productivity in manufacturing industry".

It follows that the available technical effort will be most effectively used in the national interest, if devoted to improving productivity in those basic industries which are responsible for, or are the catalyst for, the major part of the "gross national product".

Unfortunately, there is a tendency for the outlay in the basic industries on research, development, design and production equipment to be at a considerably lower proportionate rate than amongst the newer industries. Dr. Rostas estimated the average British industrial increase in productivity over 1946-1953 as $2\frac{1}{2}\%$ per man year. This is very modest when compared with an elementary handling or automation scheme which may halve the man-hours per unit produced, an improvement of 100%! A "Fortune" survey in 1955 stated the average annual improvement in the U.S.A. to be a steady 2% during the last century, tending towards 3% at the present time.

It is in these basic industries that the "three S's", Simplification, Standardisation and Specialisation, can be most productive, but difficult to bring about because of inertia and vested interests. Examples of this resistance have been the slow acceptance of "variety reduction" and "unified screw threads".

The pattern of manufacturing industry

Recent reports of the Monopolies Commission, and the several post-War regroupings of manufacturing companies, have clearly demonstrated that the more advanced the manufacturing process becomes, the more it tends to be concentrated nationally in the few large and efficient units. This trend will extend to the international field with the growth of the "common market (Fig. 1).

A good analogy is that the national economy will increasingly resemble a box packed with a few large spheres (Fig. 2) representing the big manufacturing units, with the interstices filled up by many smaller and more mobile spheres: there will always be scope for initiative and imagination!

It is in the national interest that the basic products of the few big units be highly standardised and automated, for low cost production. The bigger the unit, the nearer the economic degree of automation approaches 100%.

The functions of the smaller industrial companies will be:-

(a) making individual adaptations and composite assemblies of the basic products, by fabrication

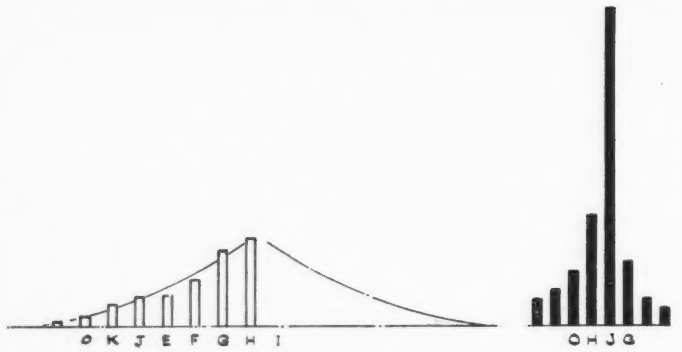


Fig. 1. The turnover figures of 15 companies in an industry followed a gaussian distribution *(in white)*, but five years later five companies were out of business, and automation by "J" has peaked the gaussian curve considerably *(in black)*.

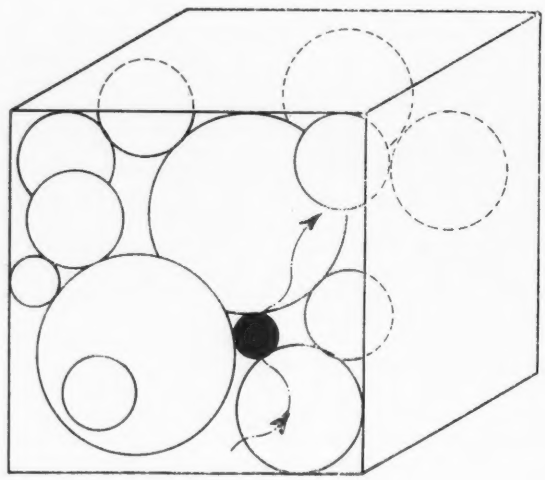


Fig. 2. The industrial economy can be represented by this model, the balls each being proportional to the size of a particular company. The large companies are virtually fixed in the economy, but the smaller ones can migrate easily, particularly the very small ones. As companies expand, they become less mobile, unless the economy also expands.

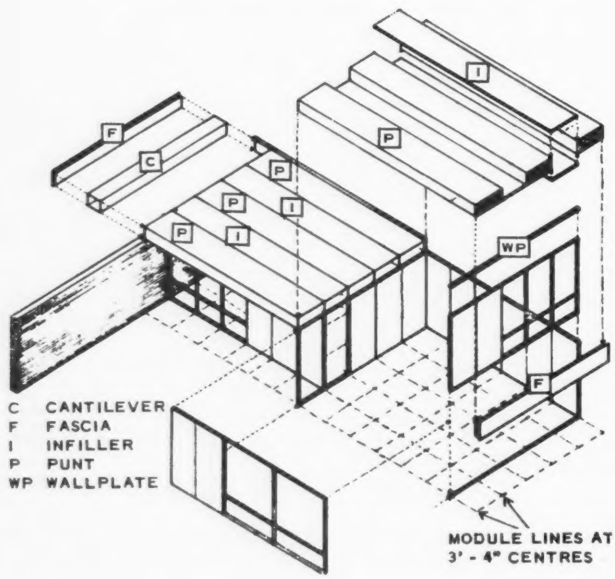
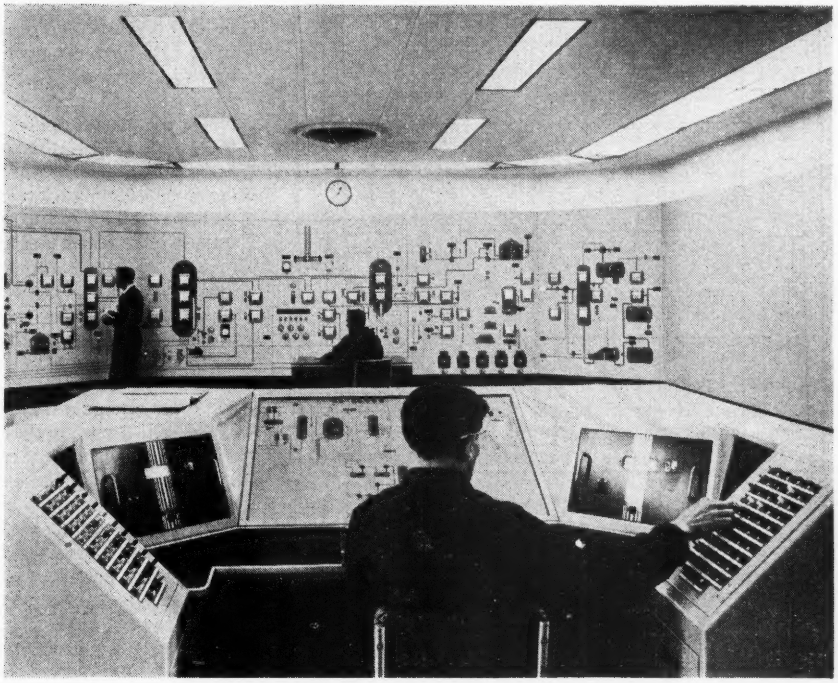


Fig. 3. Example of the use of a modular planning grid and modular building components (O.E.E.C. Report No. 174, page 148). The grid unit is 40″ (one metre).

Fig. 4. The whole oil refinery at Fawley is under the control of these few shift workers, who produce one-third of the country's oil requirements. The same proportion of the country's coal requirements engage 270,000 mine workers.
(Magnus Pyke: "Automation", Hutchinson, page 72, by courtesy of the publishers.)



and batch production, to fill the gap as standardised production reduces the flexibility of the big producers;

(b) specialised manufacture of relatively simple series of components using automated plant;

(c) miscellaneous jobbing and sub-contract work;

(d) service industries, including specialised plant installation and maintenance.

We would thus expect the building industry, for example, to fall into two groups—the mass-production of standard modular structural components and fittings, and their erection as individual structures (see OEEC Modular Studies in Building; also Fig. 3).

Similarly, specialised series of industrial components would appear, such as ranges of hydraulic motors, jacks and valves, on the pattern of the electronic component industry, which has tended to lead the way in the logic of product design: compare it, for example, with the market of roughly equal size for building and plumbing fittings and accessories! At a recent B.I.S.R.A. Conference, the absence of suitable industrial hydraulic components was noted, although in the U.S.A. there are between 10 and 20 specialised manufacturers.

Standardisation of design

Continuously-operating and fully automated plant may be so productive that one plant will supply a large part of the national requirements, and we may foresee that this will also happen internationally for some commodities, as is already the case for raw materials.

Examples of such plants in England are:-

Glass Bulbs Ltd. (GEC/BTH), making majority of lamp and valve envelopes.

Pilkington's drawn sheet glass plant, at St. Helens.

Fawley refinery; one-third of national consumption of oil products is produced under the control of a few shift workers (Fig. 4).

Standardisation of the end product is therefore essential. Many industries are covered by British Specifications, International Specifications and by commercial agreements. Other countries have gone further than we in standardising within particular industries, for example, the standardisation of electric motor frame sizes and radio valve types in U.S.A.

The usual progression of development is that a new product is devised by one company, is taken up by others, then a measure of overall interchangeability is agreed upon. If demand is sufficient, complete standardisation may ultimately be agreed, in order that manufacture can be concentrated on the most efficient producers. The consumer gains from this, but the process may take many years and be regarded as monopolistic. It would be in the national interest if standardisation could be accelerated by some degree of co-ordination in the same way that the Government-sponsored Council of Industrial Design is developing aesthetic standards in manufactured goods. This is not intended as a reflection on the British Standards Institution, which was conceived as a neutral body, seeking unanimous agreement between interested parties, rather than exhibiting leadership.

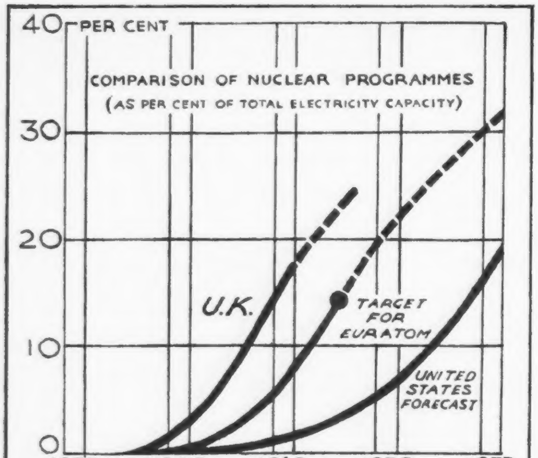


Fig. 5. The initiative of the United Kingdom in planning for nuclear energy.

(*Courtesy*: "*Financial Times*")

Standardisation cannot readily be applied to products still the subject of scientific development, but the direction of this development should at least be co-ordinated to establish common objectives. A favourable example of official action in this direction is the work of the Brunt Committee and N.R.D.C. on digital computers. The availability of transistors in this country has probably been retarded, by lack of such action amongst the interested parties, relative to progress made in the U.S.A., despite (or because of ?) the existence of an appropriate interservice body, the Combined Valve Development Committee (C.V.D.). On the other hand, our industrial approach to the peaceful uses of atomic energy has been relatively more productive than that of other countries. The graph in Fig. 5 shows a clear leadership, which historians may mark as a turning point in this country's fortunes. Despite our limited resources, when compared with U.S.A. and U.S.S.R. we may be able to muddle out a "break through" towards ways of getting better value for money in applied research.

Modular design of ranges of components

An arbitrary method of reducing the degree of decision required of the designer and user of products and components is to predetermine the range of sizes and finish in which they are available. This saves money and time, and conserves technical design effort. Variety can be retained in consumer goods by varying colour combinations in two and three tone finishes and providing optional accessories, fittings and "gimmicks".

If the intervals of size are reasonably close, only small redundancies occur—for example using a $1\frac{1}{2}$ h.p. electric motor when $1\frac{1}{4}$ h.p. is required. In practical cases the reduction in varieties may be very considerable, and a systematic approach to this task

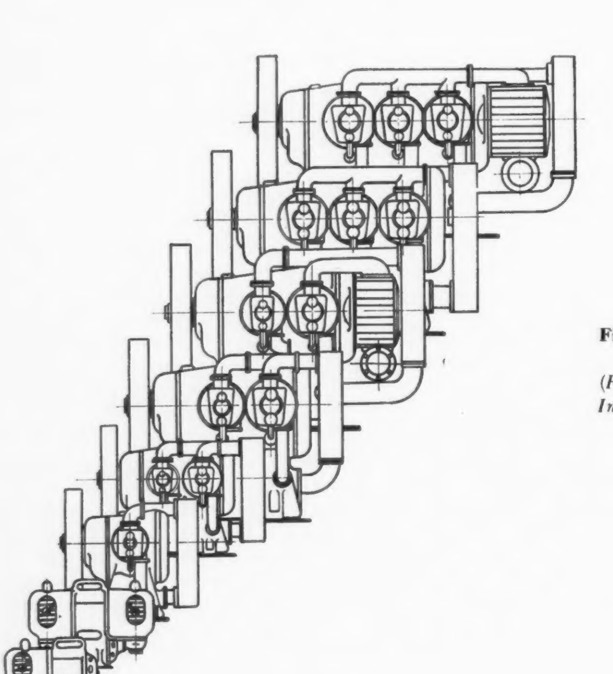


Fig. 6. A "logarithmic" range of air compressors with standardised components.

(*From a Paper by H. G. Conway, presented to the Institution of Mechanical Engineers*, 1951, *and reproduced by courtesy of the Institution.*)

has been developed recently. This not only simplifies decision making, but reduces the capital cost of stocks and their control, leading to better deliveries and greater economy over increased production runs.

A modular series of sizes may be a *linear* multiple or sub-division, as in architectural components. Design can then be carried out on a planning grid, and building components finished at the factory, with a minimum of adjustment on site.

For engineering and electrical design a series of preferred sizes or numbers is more usual. The first examples were the arbitary wire and thread gauges, which now extend to such things as the British Pharmacoepia sizes for surgical gut.

Recently it has been more usual to employ an exact logarithmic series of preferred numbers, giving regular geometric intervals, for example, the radio component numbers for $\pm 20\%$ tolerance are, 10, 15, 22, 33, 47, 68 and 100, repeated again in each decade.

These ideas are now employed in construction ranges of products as in Fig. 6, the rating of each item being geometrically related in ratio to those adjacent to it. The electrical industries seem to be more receptive to such new concepts than the mechanical. For example, electro-mechanical servo systems are more readily analysed by circuit theory and analogy, than using a mechanical design philosophy. Preferred numbers and circuit theory are two examples of simplified methods of thinking!

Sub-division of machines

The capital outlay involved in automation is such that details of design must be worked out very thoroughly. The product must be developed and subjected to trials and market research, and may be in quite large scale production before the final automated production method is laid down; this programme must be planned as a campaign and executed by a team, and may take several years. Recent figures given by Lord Heyworth for the Unilever group are that in addition to technical research and development expenditure of several per cent. of turnover, a further amount, equal to half this, is devoted to market research and trials of new products.

The sub-division of a product into components facilitates the degree to which each can be perfected: if the components are repetitive, there is a saving in tooling costs (Figs. 7 and 8). The same principle applies to the means of production, where flexible "packaged" machines for automation are to be preferred to single purpose ones. If the product can be miniaturised, miniature plant (of relatively miniature capital cost) can be used. A number of examples are illustrated in Figs. 9 - 15, showing both unitised products and unitised production machines. It is advisable to aim at flexible multi-purpose systems rather than expensive single-purpose equipment that may obsolesce. The handling and control methods of automation can also be applied to one-off production, as in the Boulton and Paul system for structural steelwork (Fig. 16).

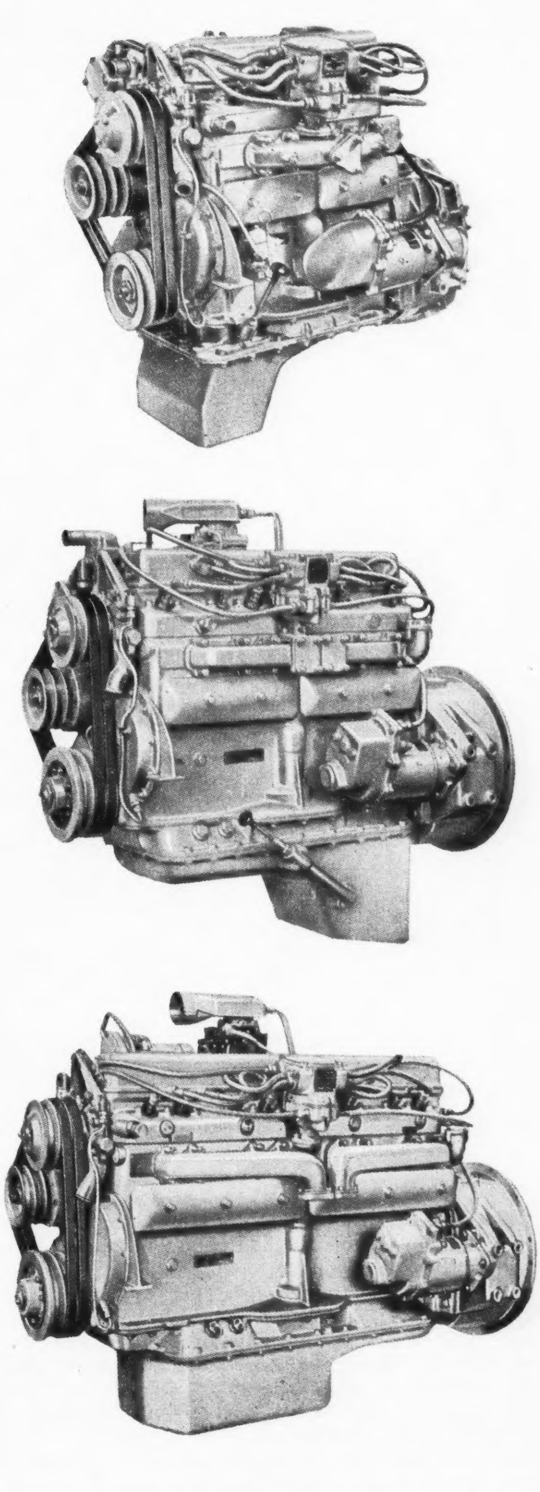


Fig. 7. These Rolls-Royce industrial petrol engines are a linear range, having 4, 6 and 8 cylinders.

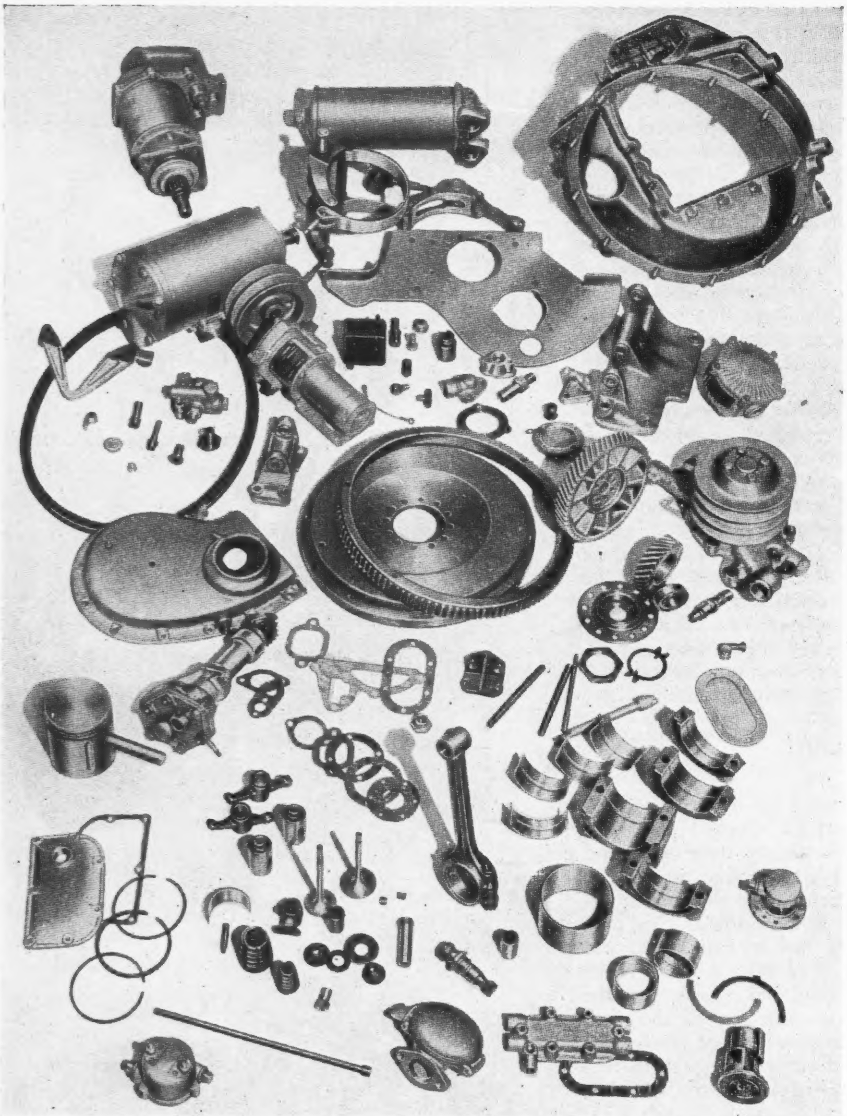


Fig. 8. These component parts are common to the whole " B " range of Rolls-Royce petrol engines.

An important advantage of unitisation of plant and flexibility in the product is that full automation can be applied gradually over a period rather than as a single major upheaval. This enables staff redundancies to be absorbed by normal wastage and by " phasing-in " the introduction of additional lines of business. *Some* of the advantages of automation are realised by adopting *some* of the features, and new plant is made to pay for itself over a period of transition, so avoiding the high capital cost of a complete shut-down and change-over. The whole situation is under control, and the rate of progress can be regulated to meet the development of the market.

While working towards 100% automation, it may be established in practical cases that the economic optimum is at rather less than 100% labour elimination, especially where the labour rates are relatively low. Although automation began in the automobile industry, conditions there are not typical of the varying requirements experienced in other industries where automation may be applied.

One type of plant as yet little used is the small-scale transportable factory, where " small scale automation " is highly desirable. It may not have the process efficiency of a large plant, but can show great economies by being on site when and where it is wanted. A fairly high degree of automation is

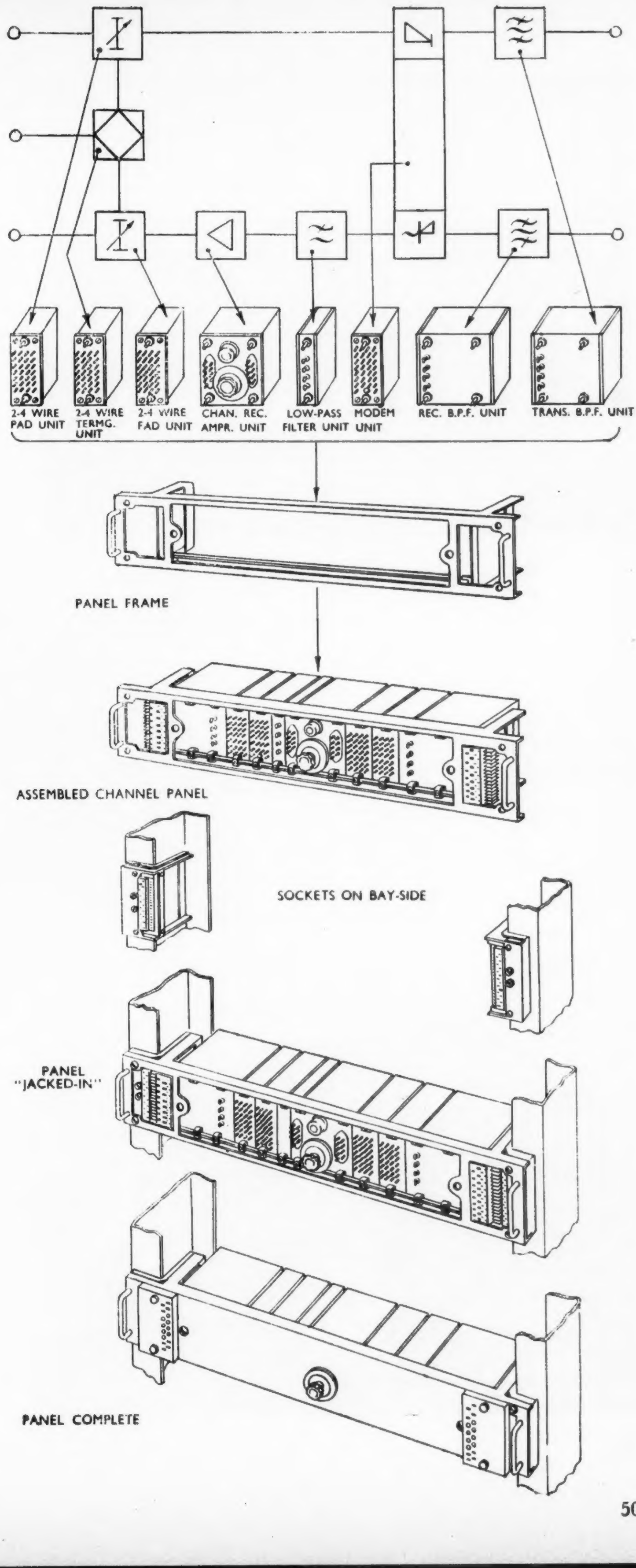


Fig. 9.
Unit construction and sub-division in telephone transmission systems.
(Courtesy: A. T. & E. Co. Ltd.)

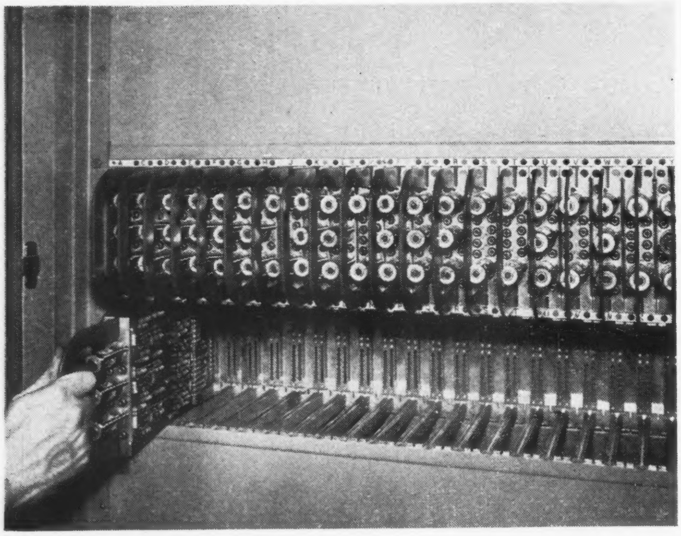


Fig. 10. The various circuits of this Ferranti electronic digital computer are sub-divided into mechanically identical plug-in units.
(*Courtesy*: *Ferranti Ltd.*)

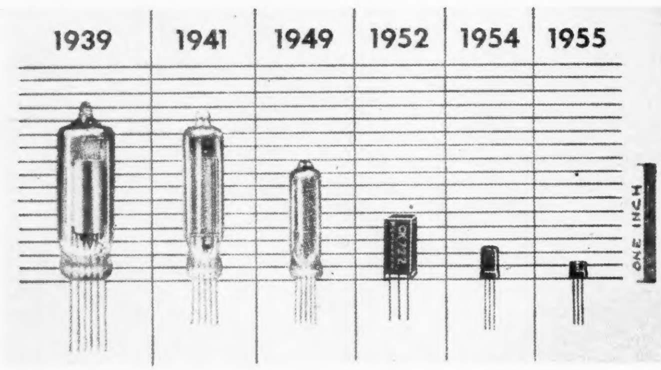


Fig. 11. An indication of the progressive miniaturisation of electronic valves and transistors.

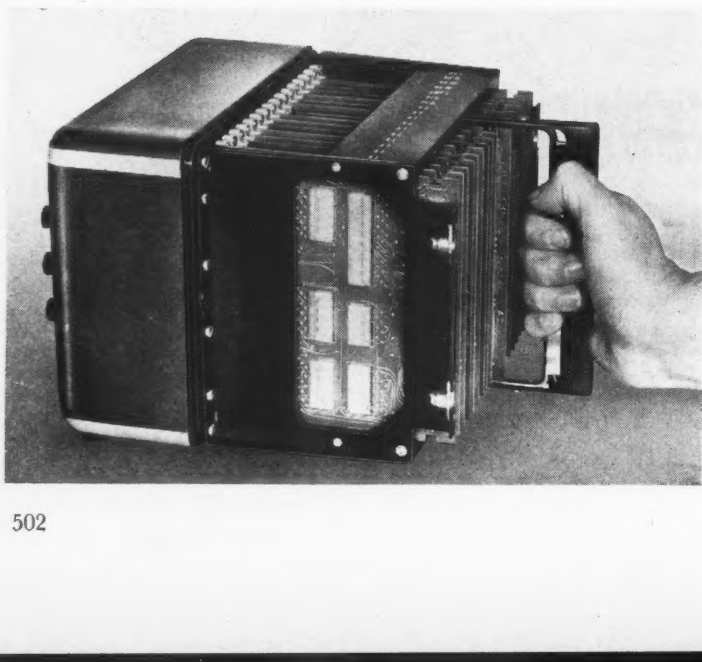


Fig. 12. Miniature components make possible this Philco (U.S.A.) digital computer comprising circuits with 1,000 transistors in a 10″ cube.
(*Courtesy*: *Philco Ltd. and "Electronic and Radio Engineer".*)

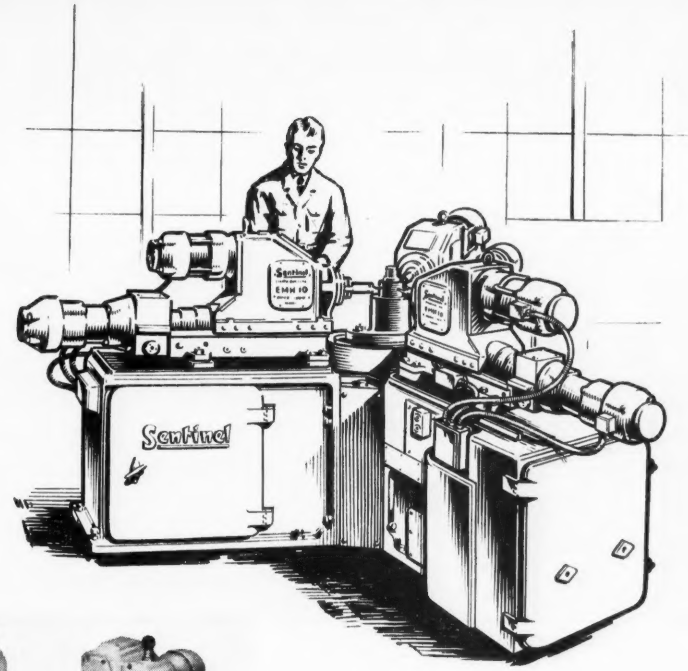


Fig. 13. A three-way horizontal drilling machine assembled from Sentinel-Renault unit heads and standard beds.
(*Courtesy: Sentinel (Shrewsbury) Ltd.*)

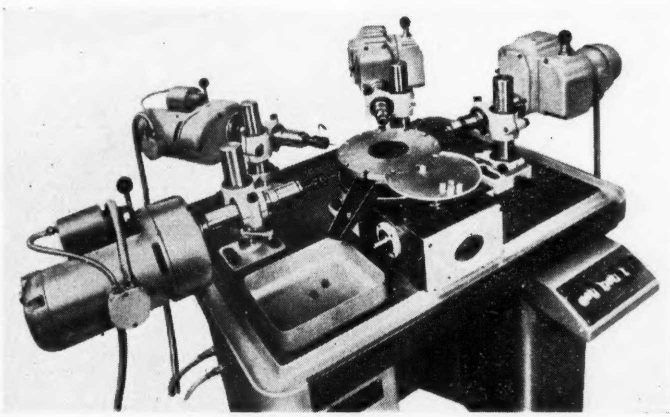


Fig. 14. Multi-station drilling and tapping machine.
(*Courtesy: Machine Shop Equipment Ltd.*)

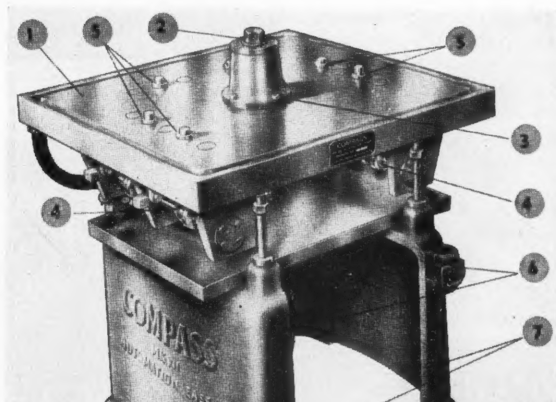


Fig. 15. The " miniature transfer line " : a rotary table with 24-station indexing, and provision for 14 separate work units, actuated by conventional " automatic " cams.
(*Courtesy: Bristol Repetition Ltd.*)

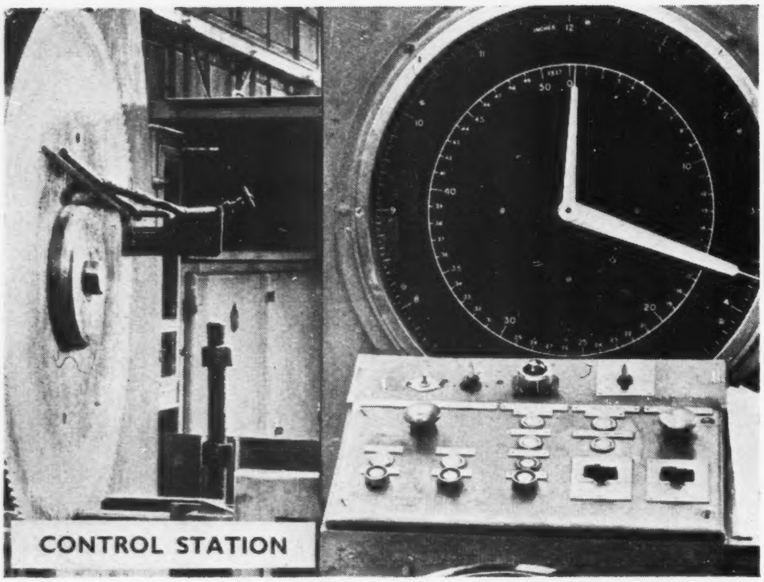


Fig. 16. Full mechanisation of the laying out, cutting and drilling of structural sections. (*Courtesy: Boulton & Paul Ltd.*)

Fig. 17. A complete mobile sawmill for logs up to 30″ dia., wheel-mounted for transport by road. (*Courtesy: Stenner of Tiverton Ltd.*)

Fig. 18. Mobile rotary newspaper press built for "The Times". This is run by a team of 16 and can print 12,500 copies of an 8-page newspaper per hour.

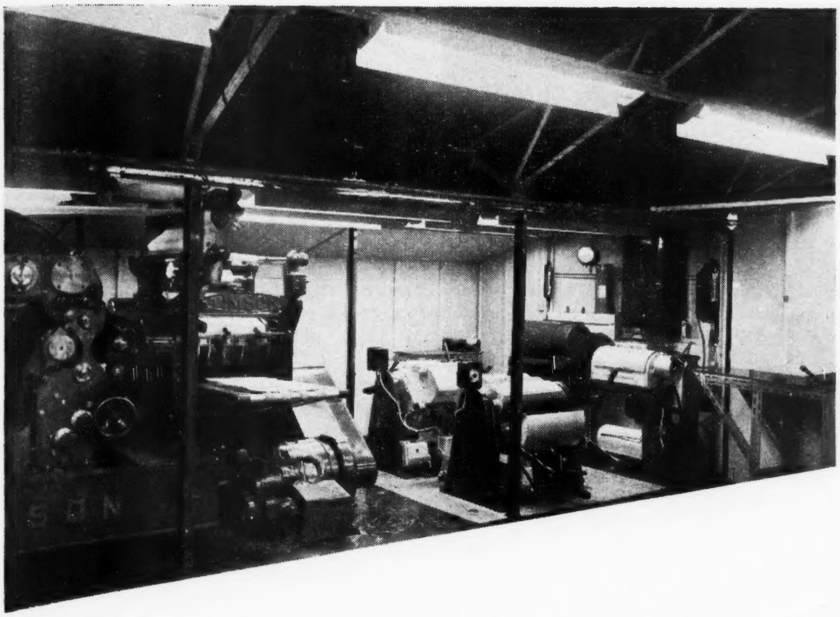


Fig. 19. Interior of the mobile press, showing one half of floor between vehicles, formed by hinged sides. There are facilities for radio-telephone and radio-typesetting.

desirable so that only a few staff need accompany the mobile factory. It is likely to have application in the dehydration and quick freezing of foodstuffs, manufacture of building materials and components, and fabrication of containers. Although still a new field of equipment design, a few examples are illustrated (Figs. 17 - 19). A half-measure is the "packaged" factory, which is simplified in design and readily assembled on site (Fig. 20). It is probable that the smaller nuclear energy units will be of this type.

A standardised unit-machine can be operated by a semi-skilled person who need not understand fully the inner mechanism. If faulty it can be exchanged quickly with a replacement unit, the repairs being carried out later at a main workshop or by a factory exchange service. Thus intelligent but technically untrained personnel can take over sections of automated plant and equipment used in the field, releasing technicians for more productive work.

An attempt is being made to encourage the co-ordination of devices for mechanical handling, controlling and computing, so that the products of various manufacturers are compatible, and may be employed together without the necessity for delving into the mysteries of their design. This trend will enable plant technicians to assemble automation systems on a "do-it-yourself" basis, using a building block technique rather than theoretical design knowledge.

One outstanding example of this philosophy is the Ferguson System, whereby a large range of agricultural appliances hydraulically controlled can be interchanged readily by an unskilled person (Fig. 21). Also illustrated is an industrial control instrument, the A.C.A. System Counter-batcher, and the expansible National-Elliott Computer (Figs. 22 - 23).

The logistics of product design

The methods of selective breeding can be said to apply in product design:

(a) The most successful machines usually have a long pedigree of experience and continuity of thought, amongst a team of experts.
(b) The quality of design and development can be improved by providing favourable conditions and facilities.
(c) Circumstances and chance can produce disappointing results, even after lavish expenditure.
(d) Occasional "sports" and outstanding examples can be the catalyst for major forward steps.

Wherever in the world an outstanding product appears, due to a combination of the above circumstances, it is best to encourage the operation of the rule "survival of the fittest". It will be short-sighted not to take a manufacturing license from another country and discontinue one's own less successful product.

The world is not large enough to support several duplicate teams of designers pursuing the same objective, and it is better that we recognise this, and free them for a concerted effort on another project, where this country may, in turn, lead the world.

The author can give, from his experience as a designer, two examples of this policy in action.

A large company decided at the end of the last War to "leap-frog" the difficulties of restarting commercial work by taking licences and designs from the U.S.A. to manufacture domestic appliances, television equipment and X-ray equipment. Simultaneously they set a design team to work on a range of industrial apparatus which is now a substantial export to the U.S.A. and the first designs in the series, dating from 12 years ago, are among the best sellers today.

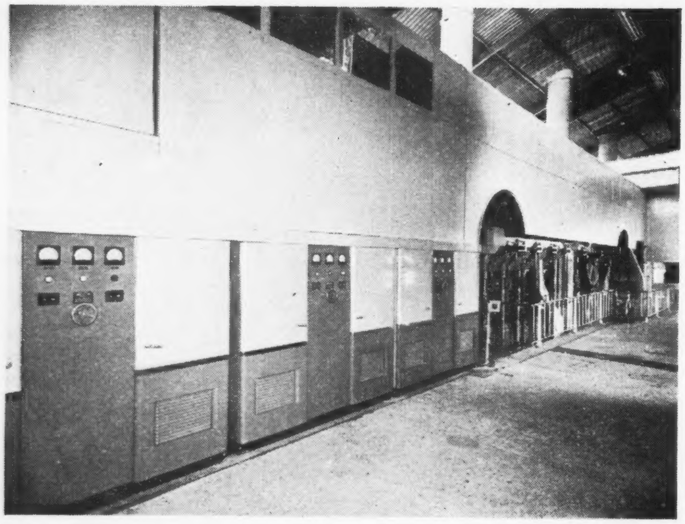


Fig. 20. The Bartrev continuous press for chipboard. Although hardly transportable, this is a good example of a "packaged" plant. High frequency heating units are in the foreground.

A medium-sized company has expanded its staff by a factor of seven in 10 years. It has taken licenses to manufacture the products of half-a-dozen American firms, but it has also by its own technical efforts achieved a leading place in the electronic computer field, and the basis of flexible organisation and engineering in its machines has been followed closely in the designs of other British and foreign companies.

No company can maintain its position for long today unless it is recognised as a leader in at least a narrow sphere of activity. The fourth or fifth place in an industry is not a happy one. The solution is to specialise and narrow down the objective so that a peak of achievement is reached, and this is most easily done by a policy of automation of the main product.

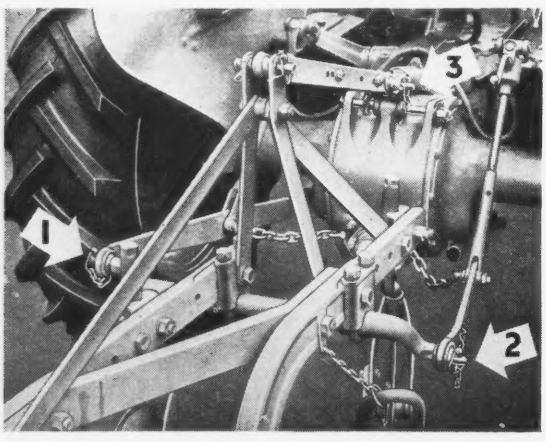


Fig. 21. The standard three-point attachment and hydraulic lift standard for all implements in the Ferguson system.

This not only leads to lower cost of production, but the statistical spread of tolerances in manufacture is brought under control and a more uniform and superior product results.

A company that pre-war sold 30% of the washing machines in this country now sells only 3% of the market. It was a good machine, and still is: it *is* the same design as pre-war, and yet the company has resources of many millions of pounds!

Another company which started with a man and a boy only 20 years ago concentrated on something very modest, ball-point pens: today they have secured the greater part of the market, both on their price and their quality. In the process they have learnt a great deal about special purpose automatic machines, and are now established machine tool builders, employing 500 people, with an annual turnover approaching one million pounds.

Specialisation is also important in the logistics of national defence. In the U.S.A. the programme policy for guided weapon production is based on the BuAER Instruction 4200.16 that all contractors (of electronic equipment) be encouraged to use mechanised production techniques, where they can substantially reduce mobilisation time, and improve reliability and productivity.

Present design for under-developed countries

The highly-specialised product designs of the Western countries are not the best solution for the economy of under-developed countries. The Cadillac and its smaller derivatives are not the best vehicles for the job, and even the Jeep may be too expensive as a mass utility vehicle. The ideal may be something like the Opperman "Motocart" three-wheel truck (Fig. 24), with varieties of locally constructed bodywork.

The capital cost of laying down mass production or an automated production line is formidable, even

for a simplified and utility product. To be justified, a life of at least 10 - 20 years is necessary before obsolescence occurs. This was in fact secured in automobile, truck and other plants supplied to the U.S.S.R. in the '20's and early '30's, as there was no objection to the continued use of designs we regarded as obsolete. The "cheapest car in the world", the Ford Popular, is mechanically the engine and transmission of 1933 and the body of 1937, a design life exceeding the famous Model T, of which 15,000,000 were built over 20 years.

A rethinking of our product designs is necessary. In a few instances this has been attempted :-

The Philips Company has, for more than a decade, pioneered the philosophy that a market for electrical devices in remote territories can only be created by supplying simple electrical power sources. Only a few hundred watts is required to operate most kinds of small electrical appliance and lighting. The thermal efficiency can be low, as wood fuel is plentiful, but the construction must be simple and the capital cost low.

The hot-air engine was developed for this purpose, and more recently a battery-less radio using transistors, and powered by thermocouples heated by a paraffin lamp. N.R.D.C. have supported the development by Ricardo of a simple steam engine to be used in the same way. Radio broadcasting is a key factor in developing the interests of the population in a backward territory, and large numbers of a very simple set called the "saucepan" radio have been supplied by a British firm to Africa. A more ambitious project was to supply 250,000 simple radios to China, their circuits made entirely by E.C.M.E., the first fully automatic factory, designed by Mr. John A. Sargrove (Fig. 25). Unfortunately, the fall of the Chiang-Kai-Shek Government in 1946 terminated this scheme.

The etched foil printed circuit technique has been developed more slowly, but has come into full production use in the last year or two.

A backward country has the advantage that it can choose the best design of its kind, and buy it assembled or "knocked down", or put in production plant and go ahead without being hampered by production facilities that already exist. It may, in

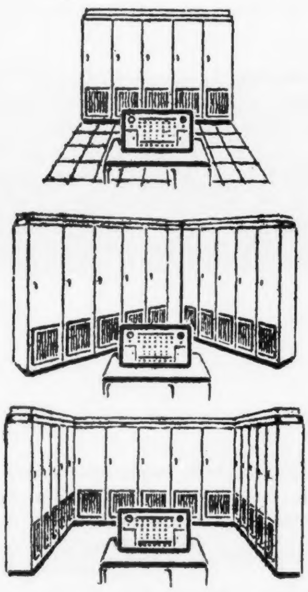


Fig. 23. Unit construction of the expansible National-Elliott computer and data-processing system : a pilot installation can be made, and expanded progressively in the light of operating experience.

(*Courtesy*: "*Financial Times*")

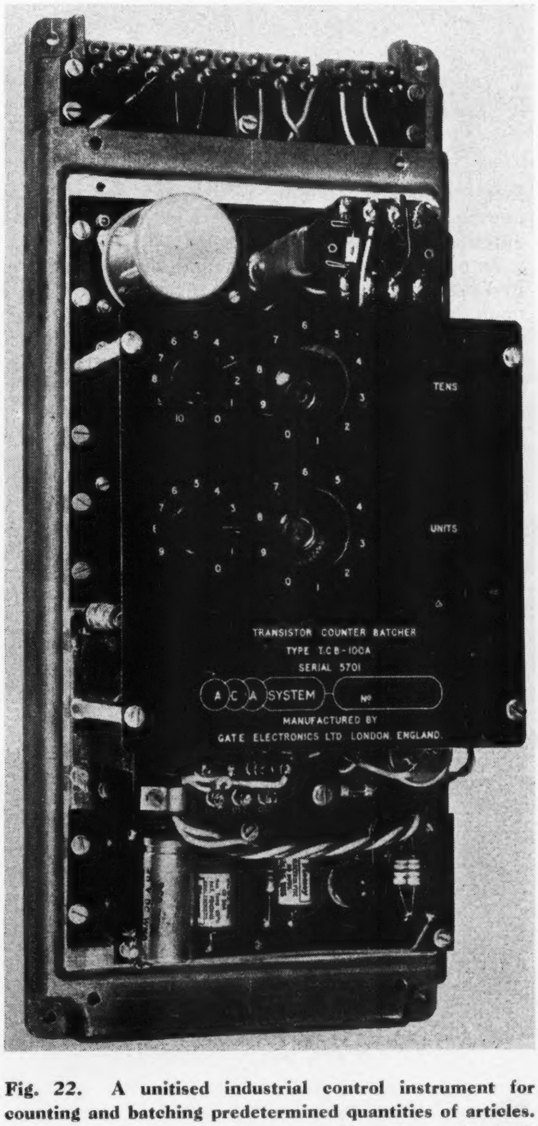


Fig. 22. A unitised industrial control instrument for counting and batching predetermined quantities of articles.

(*Courtesy*: *Gate Electronics Ltd.*)

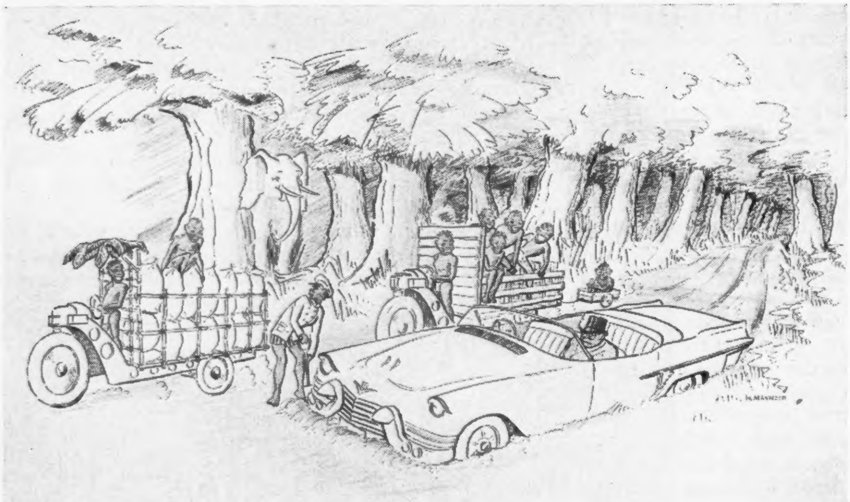


Fig. 24. The Opperman Motocart is more appropriate to under-developed territories than the modern car or even the Jeep.

fact, " leap-frog " the Western world, and it would not be surprising to see more and more advanced automation in such countries.

In our own economy, many and varied designs go into production : the fittest will survive. The Western manufacturer can " breed " his designs, as already discussed, and the under-developed countries can do what they already do with the selection of plant strains and animal breeding : they can choose and cultivate the variety most suited to *their* own environment and conditions. In the history of world agriculture this has several times changed the pattern of international trade, and we must anticipate that this will happen also in the field of manufacture.

The portable or transportable factory may become an important factor in opening up uncultivated regions. Crops, meat and fish can be processed on the spot by dehydration or deep freezing, and the bulk reduced to a minimum before shipping.

Compact, light plant, operable continuously 24 hours a day with the minimum of atention, will be of a unit-design suitable for air-borne transport if required. Simple prefabricated enclosures and staff housing can be provided, and the whole organised to move on and off site in a few hours, like a circus or a mobile military unit.

This mobility would add little to the equipment cost, probably less than the normal cost of installation on a fixed site. What would be saved are the high social costs of establishing or transferring any fixed plant and the community associated with it.

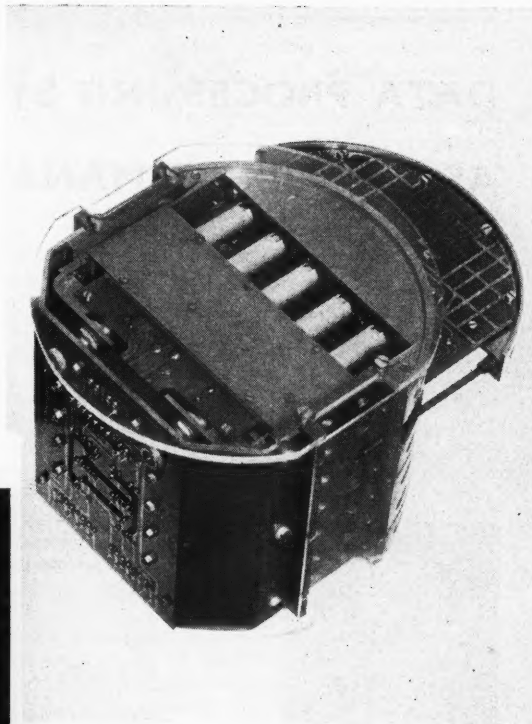
Acknowledgments

The author is grateful to Mr. H. E. Roff, Management Selection Ltd., for assistance with certain parts of this Paper; to Mr. D. T. Myers, of P. and D. Myers, architects, who is developing projects for transportable factories; and also to the organisations who supplied the illustrations.

Fig. 25. The E.C.M.E. automatic factory (1946) was developed to manufacture simple radio sets for China. The completed circuits are here shown emerging from the machine.

(*Courtesy*: *E.C.M.E. Ltd.*)

Fig. 26 *(right)*. Miniature radar receiver, with the electronic circuits on removable printed circuit leaves.
(Courtesy: Elliott Brothers (London) Ltd.)



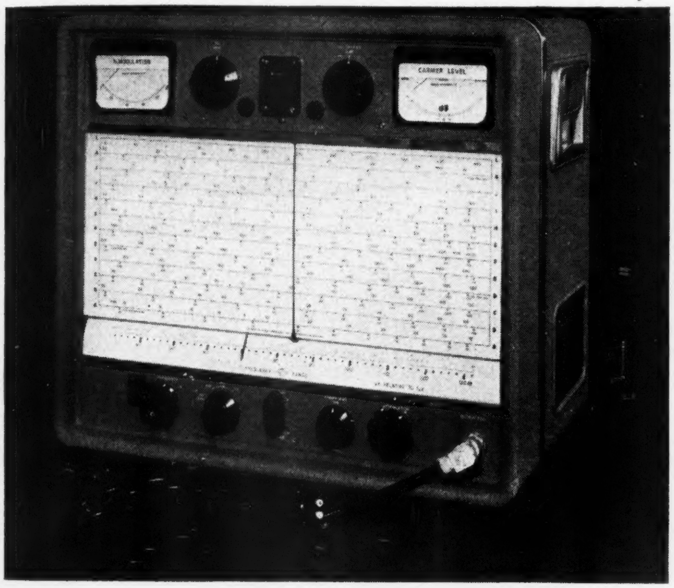
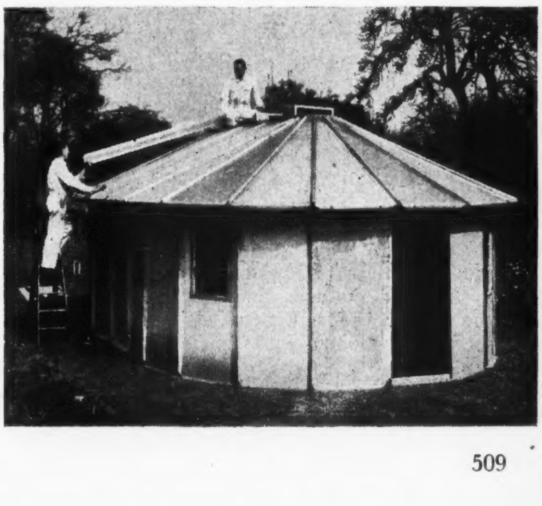


Fig. 27 *(left)*. Signal generator first designed in 1945, now selling well in the U.S.A. in 1957 : this was the first of a series of designs having a family likeness through the use of common tooled parts and accessories. The style has been copied widely both abroad and here.
(Courtesy: Marconi Instruments Ltd.)

Fig. 28 *(right)*. The Uniport metal building, of aluminium or steel, developed in 1948 for native housing in Africa.
(Courtesy: Booth & Co. (England) Ltd.)



DISCUSSION GROUP A3

DATA PROCESSING SYSTEMS AS AN AID TO MANAGEMENT

by N. D. HILL, B.Sc., A.Inst.P.

Mr. Hill was with the Research Laboratory of the General Electric Company for 14 years, engaged on research work on photometry, spectrophotometry, colorimetry, and infra-red detection devices. He then spent 10 years with Ell' tt Brothers (London) Limited at Boreham Wood and was responsible for a group of mathematicians doing theoretical work. This led to a study of computing devices and he has been interested in logical design, programming and the application of these machines to both mathematical and business accounting problems.

Six months ago Mr. Hill joined the staff of E.M.I. Electronics Limited, and is responsible for all computing sales functions there.

DURING the last few years, tremendous interest has been excited throughout the world by the possibility of using electronic data processing systems for carrying out clerical work in the office more quickly and with a smaller clerical labour force than with existing methods. The use of such systems also often provides the possibility of sifting masses of data and presenting to management summarised information in a suitably condensed and cogent form Although staff reductions may be considerable, the resulting increased speed of processing data is often more important. For example, a machine recently installed in Norwich is being used for printing demand notes to ratepayers, and it is expected that these notes will be issued within a short time from the moment when the rate in the pound has been decided by the local council. It is a psychological fact that the sooner the rate demand notes are issued, the sooner the money comes in, and it is expected that the machine will pay for itself by the savings derived from the quicker inflow of money from this and other similar work.

" Management by exception "

" Management by exception " is the phrase which has been used to describe the facility offered by a rapid data processing machine for scanning large volumes of data and printing only those items which require immediate human action, the process often being a by-product of another operation. A good example is the automatic recording and adjustment of the stock level records of raw materials and component parts in a factory. The main stock records may be kept on magnetic tape in order of item or product number, and periodically automatically brought up-to-date by feeding in information on punched tape or cards according to issues from, and receipts into, stock. The current quantities of stock and the re-ordering level, or levels, are stored along with the item numbers on the magnetic tape records. Each time the balance of any item in stock is amended, the new balance is automatically compared with the re-ordering levels. If it is found to be greater, no action is required, but if less the amount to be re-ordered, taking delivery

periods into account, is printed in the form of a list and the actual order can be printed at the same time in a form ready for posting. In this way, attention is drawn only to those items requiring action and stock levels and hence storage space can be substantially reduced on account of the tighter degree of control and the more frequent reviews of stock position. At intervals, a list of stock balances can be printed for checking against the actual stores holding; or a few items can be printed each day for spot checks. As a result, wastage can be assessed and appropriate action initiated. The control of stocks may be taken a step further by feeding to the computer the details of orders placed, with their delivery dates. The machine can then be programmed to bring to notice late deliveries, or deliveries of incorrect quantities. This procedure is particularly useful when applied to contracts for periodical deliveries.

Another example

Another example of management by exception arises in the case of sales and other statistical analyses. Records of sales throughout the year may be kept on magnetic tape in the form of information regarding quantity sold, item number, area of sale, representative, type of sale, etc. The tape may periodically be passed through the data processing system and various forms of analysis made, e.g. sales by areas, by representatives, by products or combinations of these. The results of these analyses can be automatically compared, within the system, with information relating to previous periods and attention drawn, in the output printed data, only to those changes which show significant trends either upwards or downwards. It is often possible to compile some of the required statistics during a run intended principally for other work, for example, during the invoicing job mentioned later. Indeed, this should be done whenever it can be conveniently arranged, since the figures are available more promptly and the machine is being used to its best efficiency.

Wage calculation

Another application of data processing systems which has received much attention is the calculation of wages and the printing of payslips. In this case, for each employee standard data such as fixed deductions, rates of pay, name, etc., and cumulative data, such as total wages to date and total tax paid to date, are stored on magnetic tape in clock number order. Each week, information about the hours worked and quantities produced, etc. by each employee is prepared in the form of punched cards or tape and fed to the machine where it is compared, man by man, with the data on the magnetic tape. The week's wages, tax and deductions are then computed for each man, the cumulative data in the internal store are amended to bring them up to date and payslips are printed.

After the wages for each department have been completed, summaries giving total wages for the week, total tax for the week, total deductions, etc. are printed for management and accounting use. National Insurance can be dealt with by the computer, either by printing lists of those employees for whom no deduction has been made (so that all the other cards can be franked or stamped); or, under the schedule system, the schedules can be prepared from records made each week on, for example, magnetic tape. In the case where bonuses are payable according to the combined outputs of gangs of workers, the information for all the members of a gang is first fed into the machine and then the total output and, hence, the group bonus is computed. This is then automatically apportioned among the individual members of the gang, after which the payslips and summaries are produced as previously described. An extremely useful extension of this work is the case where the input data also contain information regarding the job numbers on which work has been done; in this case, it is possible for the machine to accumulate the total labour cost of each job in its internal registers during the payroll calculations. Thus it is possible to produce summaries of labour costs several weeks earlier than by existing manual methods.

As labour costing is an important by-product of the payroll operation, so material costing can be considered as a by-product of the stock control job mentioned earlier, i.e. in addition to recording reductions in raw material stocks when issues are made, it is an easy matter to apportion the value of the stock items so issued to their respective job numbers and to print material cost summaries when required. If the cost of each batch of new material is presented to the machine with the other details when the batch is taken into stock, the average price of each commodity can be calculated and held in the store. This average is then used in compiling material costs. Alternatively, if a standard costing system is used, the variations from standard for each batch of new material can be analysed, for example, to the end products in which the material is used. Again, material costs may be based on the principle of " last in, first out ", " first in, first out ", actual, or inflated; none of these systems should present any difficulty.

Control of stocks

For the control of stocks of finished products, the input data comprise information regarding customers' orders which require to be fulfilled and receipts of finished goods from the factory. The machine holds, in its internal store, prices and detailed descriptions of the complete range of products in catalogue number order, together with quantities in stock and full details of customers' names and addresses in customer reference number order. This constitutes the basic essential information required for printing invoices and for amending quantities in stock. Attention can be drawn to any stock items requiring replenishment from the factory. Customers' statements can be prepared at intervals from the information resulting from invoice calculations, together with information on other transactions, e.g. payments, returned containers, etc. It will be noted that there is a strong similarity between the input needed for this work and that for sales analysis and, indeed, it is possible to consider carrying out the two jobs simultaneously.

Another type of job is the periodical issue of bills to consumers and arises in public utility services such as electricity and gas undertakings; this is, in fact, similar to invoicing work and normally involves much clerical effort. The information which must be internally stored for each consumer includes his number, name, address, previous meter reading, fixed charges (if any) and type of tariff, e.g. domestic, two-part or flat rate. The process of making out rate demand notes is similar to billing. It is indeed simpler in one respect, for in most cases the only variable to be given to the machine is the current rate in the £.

Data processing in banking

The banking world has not been slow to appreciate the possibilities of electronic data processing. An inter-bank committee has been formed in Great Britain to study potential applications and much work has been carried out by the working sub-committees. In particular, the possibility of the use of a network of data processing systems each carrying out the book-keeping of a number of branches is being intensively studied. Basically, the required task of each system is to accept data from cheques and credit slips which themselves have been received from the clearing stations or direct from nearby branches, and to amend each customer's account accordingly, drawing attention to any unauthorised overdrafts. Customers' statements can be produced at agreed intervals and balance lists sent to the individual branches for the purpose of dealing with enquiries. The automatic reading of the data on the cheques and credit slips will constitute an important step towards complete mechanisation; in America, it is considered that magnetic ink is likely to provide the best solution, while in this country one firm has demonstrated the optical recognition and reading of printed characters for banking and many other purposes.

So far as insurance work is concerned, many machines have been installed in the U.S.A. and, indeed, some of the first installations in that country were for work of this type. Many insurance companies at home have been studying the possibility of using electronic data processing systems to speed up their routine clerical work, in particular, the work associated with group life and pension schemes, premium billing and routine commission calculations.

In pension scheme work, for example, the major tasks are annual costing, valuation and statistical investigations and monthly accounting. The annual task involves calculating the cost to the employer of pension and life assurance benefits and producing a detailed tabular list of members showing the benefits in force. The production of a complete list of membership is virtually only possible by computer methods. The list not only gives the benefits in force for each member, but also shows the amount of any refund and surrender value which would be payable if the member were to withdraw from the scheme on the annual renewal date. This greatly simplifies the calculation of surrenders, etc. when a member does withdraw, for it is then only necessary to correct for any payments made since the last annual renewal date. Statistical investigations are made to see if actual experience during the year accords with that which would be expected if the mortality tables used for calculating premiums, etc. were an accurate forecast for scheme members. In addition, the Board of Trade requires returns showing the experience of the company during each year.

The monthly task is concerned with bringing the members' records up-to-date, calculating any changes in the monthly cost to the employer and in arrears due and recording running totals for the whole scheme, i.e. benefits, cost, valuation, etc. On the present manual system employers are charged from month to month on a " Unit Rate " basis. Each year the total charge for the scheme is divided by the total amount of pension bought during the year, to give an average charge per unit of pension bought. Changes in total pension being bought each month are then charged at this average rate until the rate is recalculated at the next annual renewal date. With a computer it is possible to charge employers the exact cost of benefits. The Unit Rate method was unsatisfactory, due to the possibility of abrupt changes in the Unit Rate during the year if a large number of employees joined the scheme.

With electronic data processing methods, new ways of valuing ordinary branch business become practicable. The normal practice at present is to group together all endowment policies with the same time to run before maturing, estimate an average age for the group, and value the whole group as if that age applied to all the policy holders. With a computer, it is possible to value each policy separately. It is also very easy to change the rate of interest at which the valuation is made.

Application to production control

It will have been noted that, in the applications mentioned above, emphasis is laid upon doing jobs which are already being done, but upon doing them with greater expedition and, in many cases, with various improvements such as more cogent and more up-to-date summaries. A further example is the application to production control in which it is possible that very great advantages may ultimately be obtained. For example, from a knowledge of sales orders and sales forecasts for a given period ahead and by using internally stored information about component parts and sub-assemblies, it is perfectly feasible automatically to break down the production programme in terms of factory machine loading, demands upon stores for stock items and items to be sub-contracted. This work is, of course, already being done in every factory but, in many cases, the volume of clerical work involved is so large that the time delay in the processing of the information results in the schedules of machine loading being out of date. This can be most damaging if, in the case of a sudden change in the order forecasts or breakdown of factory machines, the schedules cannot rapidly be revised. The rapid re-scheduling of machine processes or the ability to modify the schedules at short notice will be

of very great advantage. Rather different considerations apply to the 'production line' factory as compared with the 'jobbing' factory. In the first, much work must be done on the basis of sales forecasts, though as the product is a fairly standard one any special characteristics demanded in a particular sales order can be easily accommodated; in the second, the basis tends to be the firm sales order in which guesswork is eliminated but in which a quite different product from normal may be required. For the former, the computer can take in the sales forecasts and produce parts requirements, machine loads, etc. In addition, it will be able to analyse at high speed the special requirements of actual orders, and deduce the day-by-day work of the shops, perhaps in terms of finishes (e.g. colour) or voltages for electrical equipment. In the jobbing factory, the problem of cutting down delivery periods can be greatly eased if the full implications of a large sales order (in terms of materials, parts, machine time, or other particulars) are known soon after the order is received. It is in this type of factory, too, that the advantage of reduced stock levels of materials and parts, obtainable with the tight control of a computer system, will chiefly be felt.

From the foregoing remarks it becomes plain how intimately many aspects of data processing for a factory are related. Production control and control of stocks of materials and parts, sales order analysis, invoicing, material costing, payroll and labour costing, all have interdependent functions within the organisation. A company which has a particularly difficult or laborious problem in one field, and which finds that a computer can be of assistance, may well also find that, by extending the usefulness of the machine in other directions, a system can be devised which is coherent as a whole, as well as efficient in its parts.

Some common features

It will be noted that, in spite of the wide diversity of applications which have been briefly described above, there are common features in the processing of the information for every problem, i.e. reference data, cumulative totals, analyses, etc. are stored on reels of magnetic tape which can be considered as part of the internal store of the machine while new data corresponding, for example, to the day's or week's work are prepared on manually punched paper tape or cards and periodically fed to the system for processing. Each prospective application has to be studied in some detail, usually in a joint effort between the customer's and the computing manufacturer's staff, in order to decide upon an efficient working scheme and to establish, among other things, how much of the data can be stored on magnetic tape and how much has to be manually prepared.

In many cases, manual preparation involves a large number of punch and verifier operators, although of course far fewer than is the case with non-automatic systems and the question may be asked, "What steps are being taken, by way of development work, to reduce or eliminate these manual processes"? The answer is that a great deal is being done and some equipment is already available, e.g. punched tapes can be produced automatically as a by-product from mechanical accounting machines, time cards can be automatically punched during clocking-in in a form suitable for direct entry to a data processing machine, and equipment for the automatic recognition of typed characters has been demonstrated. Such devices are obviously of tremendous interest, but the crucial point is whether they are more economical for the required purpose than the old-fashioned human being, and it is wise to consider each application from this standpoint rather than to pursue a policy of automation for automation's sake.

An important application

An application of computers which is likely to become increasingly important in the future arises in the solution of linear programming problems, in which very many possible combinations of a set of variables are examined in order to discover those which give a maximum (or minimum) value to a certain function. A good example, and one in which the technique has been successfully used already, is transportation; given several sources of supply and several consumers, with various known costs of transport between sources and consumers, and with limits on the output of the sources, the demand of the consumers, and the capacity of the supply lines, to find the most economical use of the transport or perhaps to cause the minimum delay in deliveries. This is plainly an example with widespread application; another which arises in the petroleum industry is the blending of grades of oil, within specified characteristics, and with set limits of supply and demand, to give maximum profit. Again, the use of machines in a factory might be more efficiently organised, with less idle time, if the flow of work could be planned to avoid bottlenecks and clashes of priority.

In general, the method can be used (as its name suggests) whenever the relationship between the variables of a problem are linear, and in fact a solution based on an assumption of linear relationships may be the best solution even though the assumption is not precisely justified. Problems of this kind often occur, and the use of a computer may well be the only way of getting a definite answer quickly enough to be useful; particularly is this so when the problem occurs regularly in the same form, with changes only in some values of the constraints.

It is perhaps interesting to reflect that the majority of American data processing systems use some form of binary-coded decimal coding, whereas most British machines operate in a straight binary code which requires conversion to and from sterling, decimals, etc., as the case may be.

Presumably, American designers have considered that decimal working is compatible with their decimal currency system, whereas British designers, who have to contend with comparatively complicated conversions from the sterling currency system, have decided to employ a code which is more economical in terms of storage capacity and which provides simpler and

faster arithmetic units. As more and more advantage is taken of the high potential computing speeds afforded by modern electronic data processing systems, it is possible that straight binary working may become more popular with American machine designers and users. It is extremely interesting to note that the latest model manufactured by a large American company is to work in this code.

The need for forward planning

It will be seen that electronic data processing systems are unlike practically any other machine which can be bought, in that they cannot just be installed and handed over to someone to use. They require to be fitted into the organisation, and sometimes the organisation itself requires modification of its methods if the most efficient operation is to be achieved. When this is done, however, the system will provide handsome dividends. Moreover, it will be evident that one cannot afford to ignore the advent of these systems if one wishes to compete successfully in business.

Faster processing of data can be the means of providing a vital contribution towards our standard of living, by increasing the proportion of productive to non-productive labour.

In a survey of this kind, it is difficult to give more than an indication of the potential advantages of the application of electronic data processing systems in certain specific cases, but enough has been said to suggest ways in which such systems can be used by taking full advantage of their capacity for holding large volumes of internally stored reference data, both fixed and variable, and their ability to compare and merge these data with new input information on punched tape or cards. These facilities constitute a revolution in methods which is comparable with that brought about by the introduction of mechanised accounting procedures, but having far greater potentialities.

" THE EFFECT OF AUTOMATION ON MANAGEMENT ORGANISATIONAL PRINCIPLES AND PRACTICES " — *concluded from page 493*

hours are worked on the various jobs, I think the automation people have a point when they suggest that the working week can be legitimately shortened, if it is work.

When you gather it all up and ask what the answer is, I can see only one, and that is education. It seems to me that we have to plan for life-long education. I am getting tired of the technical people getting tougher and saying : "We have an education representative ". You say : " How about the arts and the universities ? " ; and they reply : " We didn't invite them ; we just thought that we would have a technical person ". " How about the preparatory work to get people ready for this instruction ? " " We didn't think about that." I should like to see the kind of evaluation which says that education starts with the child in the home and should go on all through his life, and there must be representation of every horizontal layer in our education system. Once we have that concept of a life-long education, with a willingness to evaluate what we have and to look on the present as a stage in an endless process, it seems to me that we shall be able to face not only the challenge of automation but any other kind of challenge which may come along.

RESEARCH PUBLICATIONS

The Institution is advised by PERA that Dr. G. Schlesinger's book on " Accuracy in Machine Tools : How to Measure and Maintain It " is now out of print and cannot, therefore, be supplied. The following I.Prod.E. publications are, however, still obtainable from PERA at " Staveley Lodge ", Melton Mowbray, Leicestershire.

" Practical Drilling Tests " by D. F. Galloway and I. S. Morton. Price 21s.

" Machine Tool Research and Development " by D. F. Galloway. Price 10s. 6d.

" Surface Finish " by Dr. G. Schlesinger. Price 15s. 6d.

It is also announced that the following PERA research reports are generally released to the public, and may be obtained from Melton Mowbray at the prices stated :

" Packaging of Engineering Equipment." Price 10s. 6d.

" Packaging of Engineering Equipment." Price 10s. 6d.

" Hi-Jet System of Cutting Oil Application." Price 7s. 6d.

" Notes on Selection and Use of Soluble Cutting Oils." Price 10s. 6d.

" Drilling Titanium Alloy Ti 150A " (Press reprint). Free.

" Memorandaum — Developments in the Study of Metal and Plastic Slides " (photocopy). Free.

HIGH SPEED PRODUCTION FROM BAR MATERIAL

by R. JACKSON, A.M.I.Prod.E.

Abstracted from a Paper given to the Birmingham Section of the Institution, March, 1956.

After an apprenticeship and a period in the Tool Design Office at Alfred Herbert Ltd., Mr. Jackson joined Wickman Ltd., where he is now Chief Equipment Engineer. He has a long and extensive association with the tooling and equipment side of multi-spindle automatics.

THE general principles of automatic bar production are common to both single-spindle and multi-spindle machines. Such features as the use of collets to grip the bar, and the use of cams to feed the tools into the work, form part of the basic design of all automatic bar machines. But within these broad principles methods of operation vary between machines, and a summary of these differences, and of the fields of application which result, will be helpful to an appreciation of the scope and advantages of automatic machines.

Since the machining is spread out over the stations of the machine, it follows that the time of the longest operation governs the time between indexing movements and, therefore, the cycle time. We, therefore, arrive at the paradoxical statement that the time of the longest operation (of perhaps 15 or so operations) is the time taken to produce a completed part. Clearly this represents a great advance over a capstan lathe, where the total of operation times is the time required to produce a component. For instance, a water tap spindle can be produced on a six-spindle automatic, by spreading the work over the six available stations, in 4½ seconds, whereas a capstan would require at least 30 seconds, plus about 20 seconds for a second operation of milling the flats — a process completed within the cycle of the automatic. To carry the comparison a stage further, the automatic would produce 3,800 tap spindles per working day (allowing 2 hours for re-loading bars and clearing the work), with one operator, while the capstan and milling machine would require 4 days on one and 2½ days on the other operation to produce the same number of parts.

Though the multi-spindle automatic can produce simple parts using only form tools on the normal slides, it is usual for there to be at least one standard attachment on each set-up. Standard attachments include devices for threading, tapping, chasing, high-speed drilling, reaming and picking up of components, which enable all the normal operations applicable to bar production to be performed.

A good example of the use of standard attachments is shown in the diagrammatic layout (Fig. 1) for producing union nuts, used in the automatic advance and retard system in motor cars and, therefore, required in large numbers. This six-spindle layout produces the completed part in 5½ seconds, whereas previous production time on an automatic screw machine and a capstan lathe was over 20 seconds. A skilled capstan operator could, in fact, only just equal, in this one operation, the multi-spindle's time for the complete process. The thread behind the shoulder is cut by the single-pitch chasing attachment, and the other by the die-head, while the pick-up and back-drilling attachment is used to machine the rear counterbore and radius, thus completing the component. Minor variations in the layout would allow a wide variety of types and sizes of double-ended component to be produced.

Since the spindle speed of a multi-spindle machine is constant during a run, die-heads and taps must

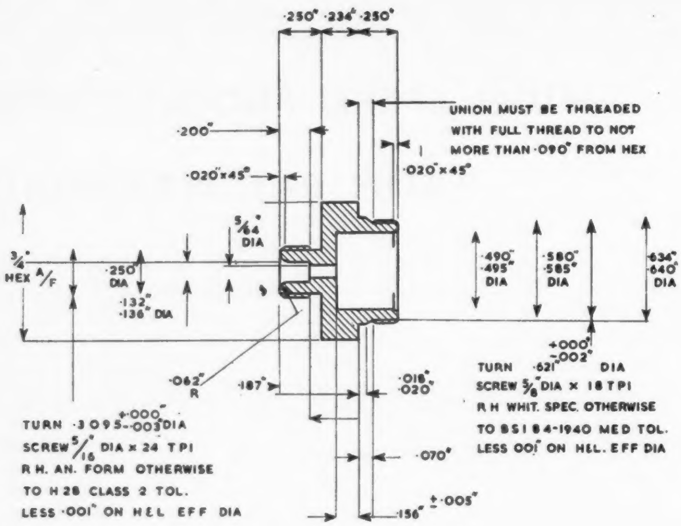


Fig. 1. Production layout for a union nut :

Station 1 Drill part-way, turn thread diameter and break down rear.

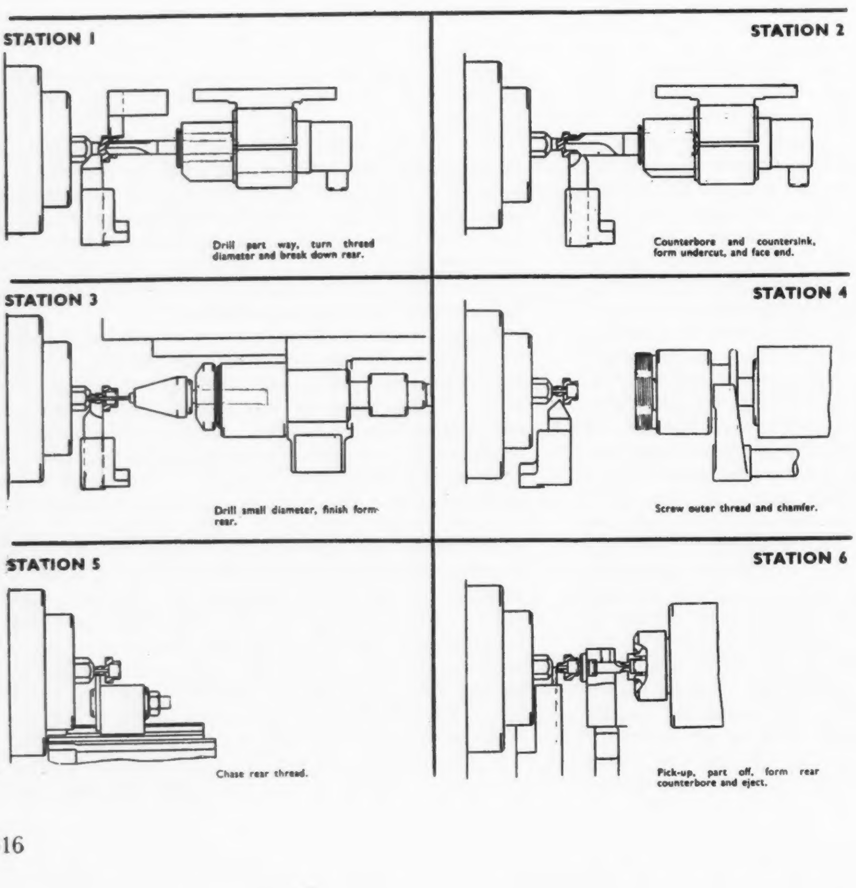
Station 2 Counterbore and countersink, form undercut, and face end.

Station 3 Drill small diameter, finish-form rear.

Station 4 Screw outer thread and chamfer.

Station 5 Chase rear thread.

Station 6 Pick-up, part-off, form rear counterbore and eject.



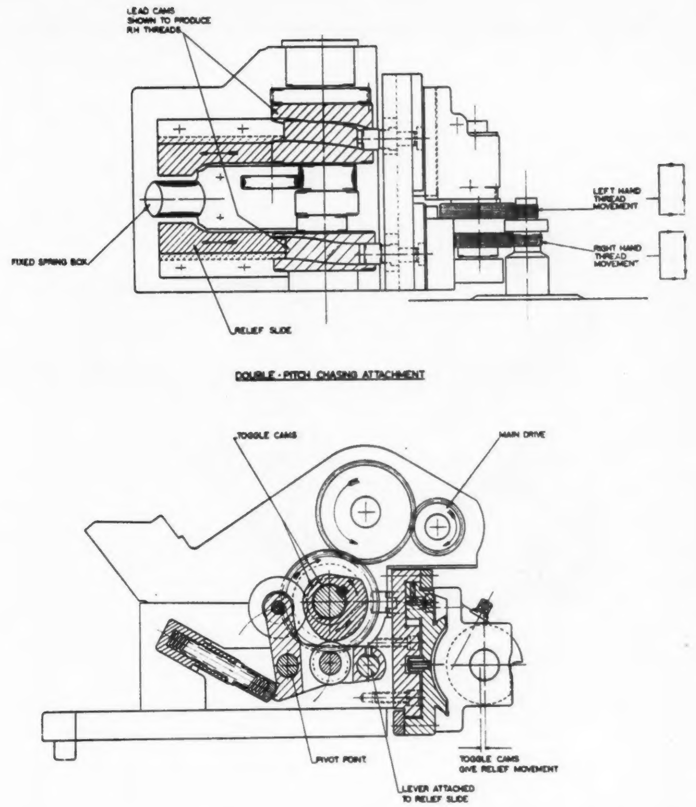


Fig. 2. A two-pitch thread chasing attachment.

revolve to give the correct differential speed. For producing right-hand threads the threading spindle runs slower, and for left-hand threads, faster, the usual ratio being 5:1, which means that for a normal right-hand thread the die-head spindle is running at four-fifths of the main spindle speed. While this is also true of a tap, the necessity of reversing a tap to withdraw it calls for a double clutch, which is thrown over when the tap has finished its work. The tap then either speeds up or slows down, according to the hand of the thread, the difference in speed being about 2:1, and reverses out. These attachments are fed independently, the feed being calculated according to the pitch and ratio used. Two-pitched thread chasing attachments can be used for cutting two threads separated by a narrow shoulder, thus eliminating the need for a second operation and the difficulties of holding a threaded part. They can also be used to cut a thread behind a shoulder (Fig. 2). The chasing tools, in the present instance of circular form with the thread ground on the circumference, are fixed to holders mounted on slides. These slides are actuated by lead cams supplied according to the pitch required, and are carried on a base slide operated by a toggle cam. At the start of the operation both base slide and tool slide move together ; the radial movement controlled by the toggle cam is then arrested, and the lead cam moves the tool slide longitudinally to cut the thread. The complete threading operation is performed in a series of cuts controlled by the cross slide.

This type of attachment is usually driven at a ration of 6:1, that is, six revolutions of the work-spindle to one of the cams. Since with this ratio the chaser passes over two threads per revolution, the number of threads on the chaser must be worked out to give the required length of thread. This type of attachment has given satisfactory service for many years.

Thread rolling gives roughly 14% to 20% stronger thread, very good finish and great accuracy, and can be used for forming threads behind a shoulder, thus eliminating further operations. Three-roll heads, similar to die-heads, though only suitable for thread-forming on the front end of a component, are being increasingly used and have a very long life. For example, a $\frac{5}{8}''$ by 18 t.p.i. thread on mild steel tube,

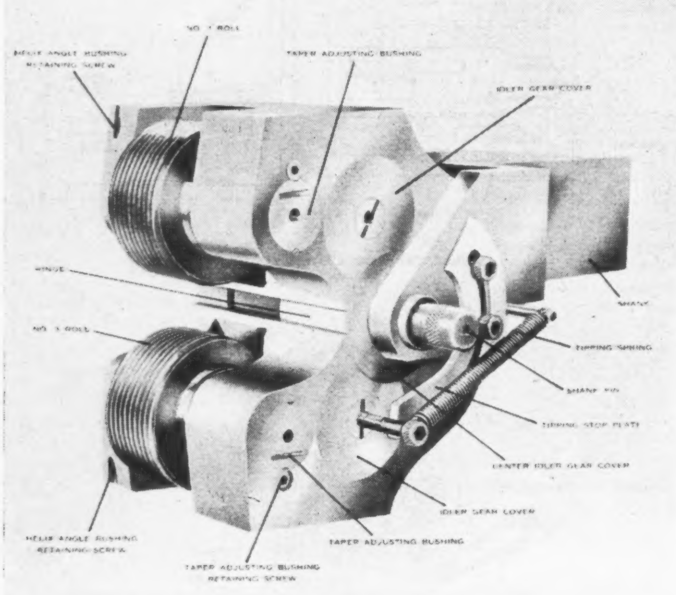


Fig. 3. A thread rolling attachment.

whose outside diameter was about 0.6″, was produced on 100,000 components without re-grinding.

Single or double roll heads are used for forming threads behind shoulders, again saving second operations. The simple single roll, consisting of a roll carried in a holder mounted on the cross slide and fed radially into the work, sets up considerable radial thrust on the spindle bearings and is, therefore, used only on commercial yellow brass and some of the freer cutting mild steels. The double roll attachment consists of two rolls mounted in a holder, which is pinned to a block mounted on the cross slide, thus allowing the rolls and head to float. The two rolls then pass over the work like a caliper gauge, and are geared together to keep "starts" in relation (Fig. 3).

Successful thread-rolling calls for machining of the blank to close tolerances, for which a shaving tool is desirable. It is also desirable to complete the thread-rolling as fast as possible, and this is usually done in about 20 revolutions, allowing three or four revolutions for dwell. The following points have to be taken into account when a thread-rolling operation is being considered :-

1. Material ; carbon content must be between 0.25% and 0.35% and the ductility about 18%.
2. Strength of work (the support of a centre or roller steady may be necessary).
3. Size and pitch of thread.

High-speed drilling attachment

Since a machine's spindle speed is often determined by the requirements of some other operation, it is often necessary to rotate the drill, especially if of a small size, to obtain correct surface speeds. Such attachments may be mounted on an end-working slide, and the drill is rotated against the direction of rotation of the machine spindles. For example, a drill speed of 500 r.p.m. and a spindle speed of 500 r.p.m. gives an effective drilling speed of 1,000 r.p.m., which also allows the feed rate of the drill to be reduced. The speed ratio is normally 2:1 or 3:1.

Back burring attachment

The purpose of this attachment is to eliminate second operations, by removing the "pip" often left by the part-off tool, by making a shape on the back of the component such as a ball peg, or by picking up the component and counter-boring or chamfering the back of a bore. Geared to run at the same speed as the spindle, the attachment is fitted with a collet which opens and closes at the appropriate times, the whole being actuated by an individual cam timed to operate at the correct time in the machine cycle. The back-burr or counter-bore tool is held in an arm which is swung into position. The attachment advances to the tool, and then withdraws and ejects the component.

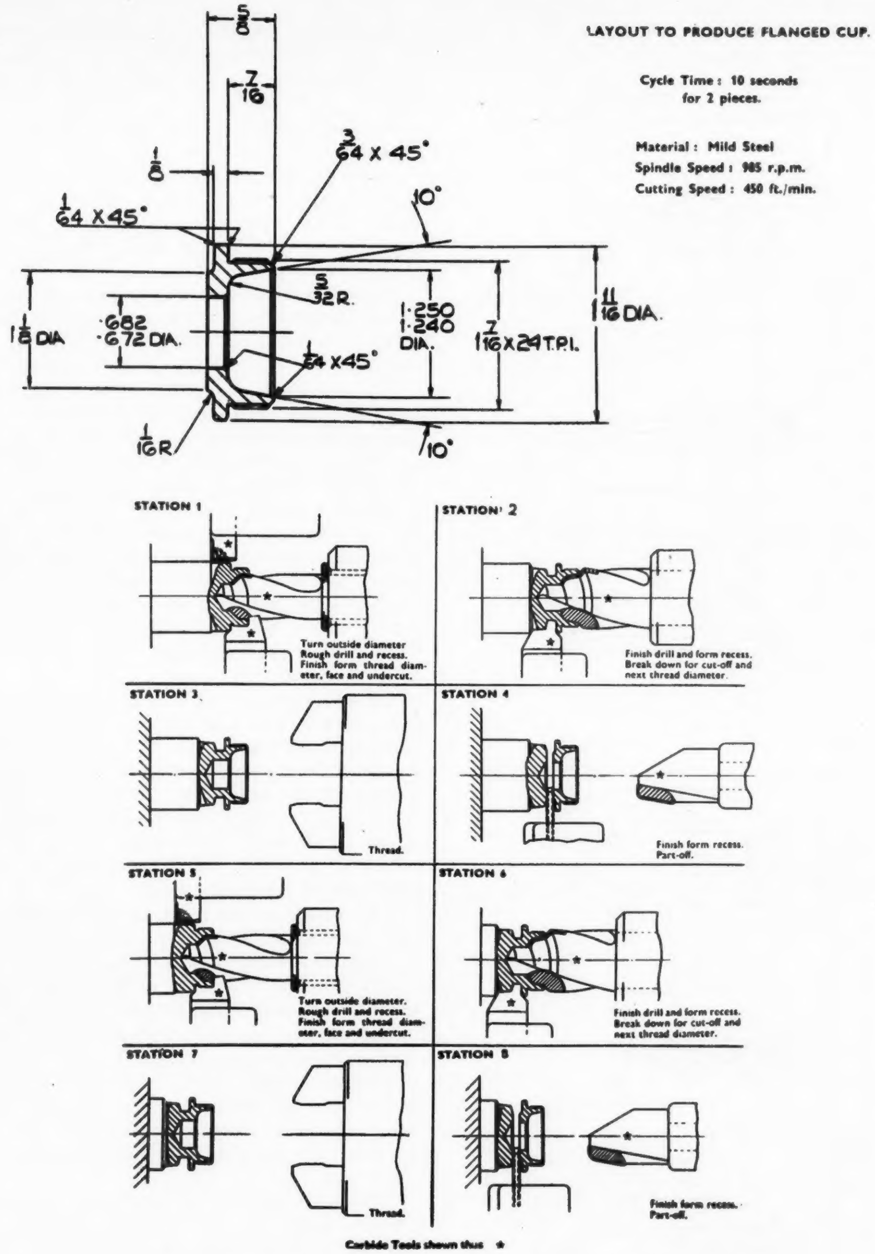


Fig. 4. Production layout for a flanged cup (double bar feed) :

Station 1	**Turn outside diameter, rough drill and recess. Finish-form thread diameter, face and undercut.**
Station 2	**Finish-drill and form recess. Break down for cut-off and next thread diameter.**
Station 3	**Thread.**
Station 4	**Finish form recess ; part-off.**
Station 5	**Turn outside diameter, rough-drill and recess. Finish-form thread diameter, face and undercut.**
Station 6	**Finish-drill and form recess. Break down for cut-off and next thread diameter.**
Station 7	**Thread.**
Station 8	**Finish-form recess ; part-off.**

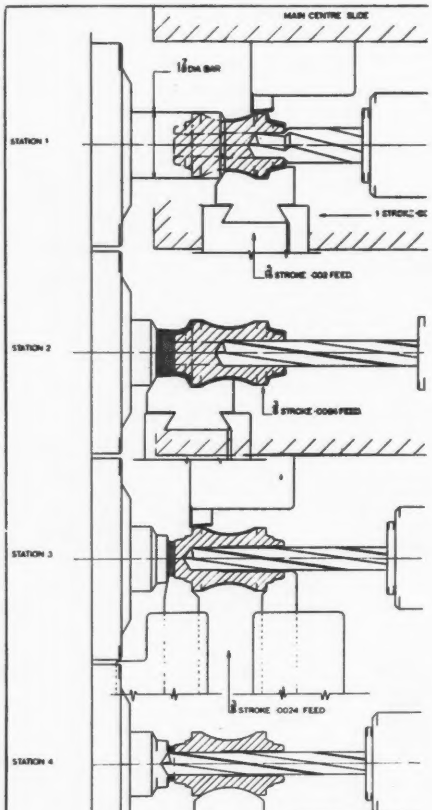


Fig. 5. Production layout for a worm gear blank.

Besides the special attachments detailed above, all the conventional bar-working tool-holders are used in multi-spindle bar automatics, such as roller steady turners, drill holders, recessing slides, various types of form tool-holders for circular type tools, prismatic type tools, flat tools, etc., to name only a few.

Another method of increasing production speeds, used mainly on six-spindle machines turning out fairly simple components, is the conversion of the machine to double bar feed (Fig. 4). This means that the number of stations available for operations is halved and the number of components produced per cycle doubled. Such a layout has been used to produce brass nuts, two per cycle, in a time of 3.9 seconds.

The general capabilities of the multi-spindle machine may be illustrated by the following description of the layout for producing a worm gear blank in nickel molybdenum case-hardening steel on a six-spindle automatic (Fig. 5).

The machining is divided between the six stations for simultaneous operation. Drilling through the component is spread over four stations, the two bores being reamed in the fifth station from an independent end-working slide. The finished parts are cut off into a tube mounted on the last station, and as the tube fills up the components fall from the back into a work-chute.

On the layout shown the spindle speed (determined according to the material to be cut) of 170 r.p.m. gives a surface speed of 83 f.p.m., the drills cutting at about 30 f.p.m. Feed rate (also governed by the nature of the material) is further controlled by the form tools in first two positions, which require a stroke of about $\frac{3}{8}''$ and a feed rate of about 0.0025", which is about as much as could be expected for this type of forming.

The stroke of the main block, worked out to split the drilling between four positions, is 1", provision having been made for the tools to commence their working stroke just short of the point where cutting begins. For the reaming operation, which requires a stroke of $1\frac{7}{8}''$, an independent end-working slide is used, with a proportionately higher feed rate due to the longer stroke. This, being the longest single cut, is the time for producing the part, but the feed rate limit of other operations controls the time cycle. In this case the controlling feed rate is that of the form tools.

The example above represents a very ordinary process, but the desire to eliminate second operations has led to the design and successful use of many unusual attachments which add further operations to the set-ups, thus allowing more complex components to be produced quicker and at lower cost than before. Some examples of these special jobs are listed below.

An excellent example of tooling for high production is the layout for a tap spindle (Fig. 6), which is produced in a cycle time of $4\frac{1}{2}$ seconds. The rough turning of the shank is halved by the use of a turning slide pushed from the centre block ; this consists of a slideway mounted on the cross slide with a sliding holder, which is connected by a bracket and link to

Fig. 6. Production layout for a tap spindle :

Station 1 Break down shank diameter, turn thread diameter.

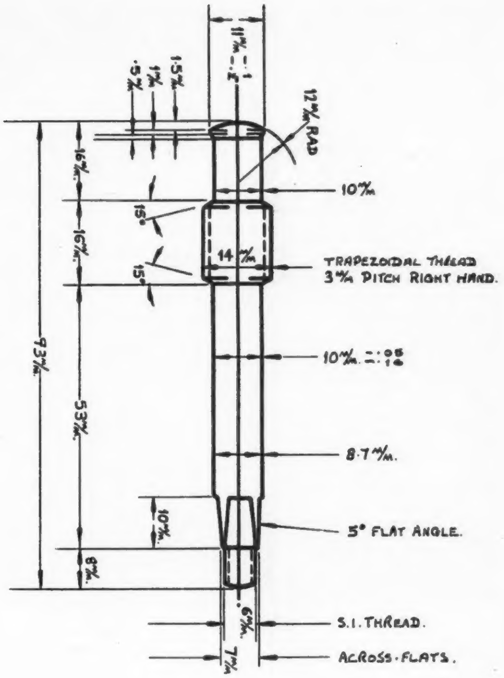
Sation 2 Steady and long turn shank.

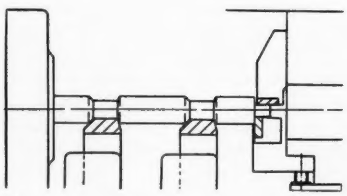
Station 3 Thread large diameter.

Station 4 Steady, end up and skive shank diameter.

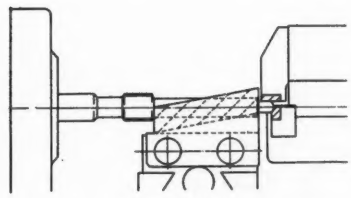
Station 5 Generate flats, form rear and chamfer rear of large thread.

Station 6 Thread and form cut-off.

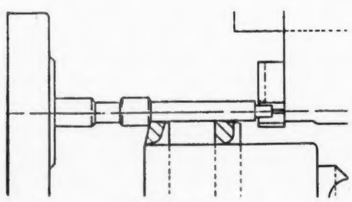




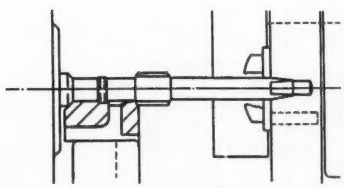
Station 1



Station 4



Station 2



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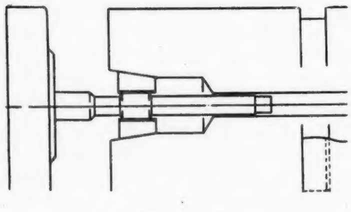

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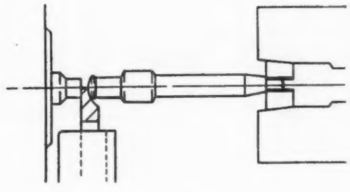

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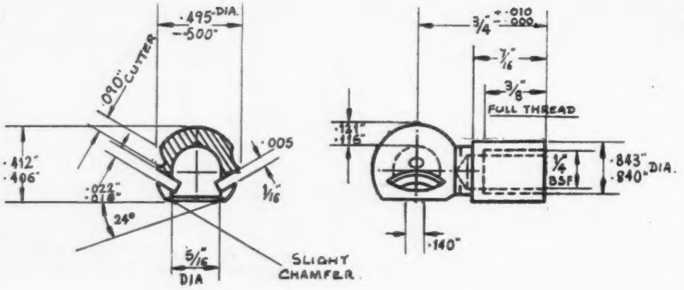


Fig. 7. Production layout for a snap lock socket :

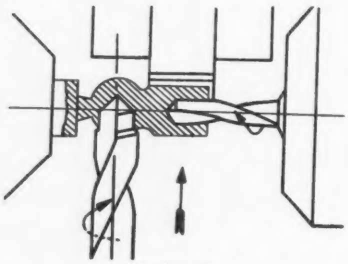
Station 1 Feed-out bar. Knee turn diameter, centre drill, face end and part-form spherical radius *(not illustrated)*.

Station 2 (Stationary spindle.) Drill part way for tapping, part-drill socket and form flat.

Station 3 (Stationary spindle.) Finish drill for tapping, mill slots and dimples each side spherical radius.

Station 4 (Stationary spindle.) Tap $\frac{3}{8}$" B.S.F. finish drill and form spherical radius in socket.

Station 5 Advance pick-up to hold component, finish form outer spherical radius and part-off. Withdraw pick-up attachment and eject finished component *(not illustrated)*.



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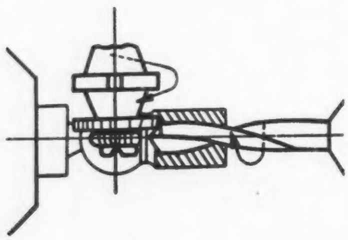

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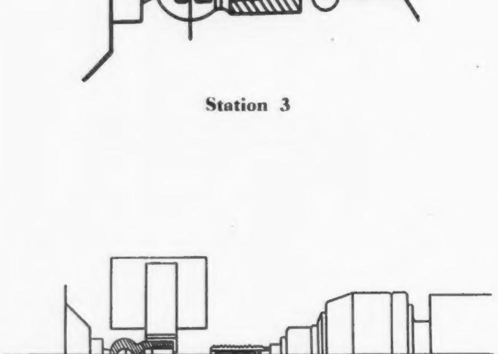

Station 4

the main tool slide. The shank is then skived from the cross slide, thus giving a fine finish and obviating a long stroke on the main tool slide. The square, generated in the fifth position to avoid a second operation, is produced by rotating a cutter at twice the speed of the workpiece.

Another very useful feature is the spindle stopping mechanism, which involves each spindle being fitted with a multi-plate clutch and brake, with an operating glut controlled by cams mounted round the spindle drum. This allows cross drilling, flat milling and other special purpose attachments to be used when a stationary spindle is required. Illustrative of this is a special set-up for producing ball joints of a control mechanism used on the steering column, gear changes, carburettor controls, etc., on motor cars (Fig. 7). Cross drilling and reaming are performed by the use of the spindle stopping device, these drills being driven by a ½ h.p. 1,420 r.p.m. motor through suitable gearing. Slots are milled in the spherical end by milling cutters pivoted on arms operated by tapered wedges pushed by an end-working slide (Fig. 8).

It is sometimes found convenient to apply magazine loading to bar automatics for performing second operations or for loading components which must be produced from billets. Examples of components most suitable for magazine loading are gudgeon pins (made from carburised blanks) valve guides, and second operation work on pre-machined blanks, such as shell cases and 22 mm. shell bodies. Types of magazine attachment include hoppers, drums, conventional loading chutes and conveyor feed types, all of which are used for positive injection and ejection of the workpiece in and out of the collets. Basically, the magazine moves forward to bring the part opposite the machine spindle, the collet is opened and the plunger, carried in an independent end-working slide, pushes the part into the spindle against a stop. The collet then grips the component and the magazine withdraws, the movement being controlled by a cam timed to the machine cycle.

The machine operations are then carried out, spread out over the various spindles, the collet opens and the piece is ejected by a plunger operated through the spindle bore. It is, of course, necessary to provide safety devices to cover all the foreseeable points of failure. This is done by the use of electrical limit switches at all danger points, wired either in series or in parallel, to cut out under any abnormal conditions. A solenoid is employed, arranged to knock out the machine feed.

Magazine loading

The application of magazine loading illustrated (Fig. 9), was fitted to a five-spindle bar automatic to produce gudgeon pins in two stages in batches of 8,000 pieces. The first stage consisted of magazine feeding the billets into the machine and part machining. The second stage uses the same magazine feeding arrangements for loading the part-machined billet into the machine the other way round, and completes the machining of the part to the auto stage drawing. Whereas a normal hopper feeding

(*concluded on page* 531)

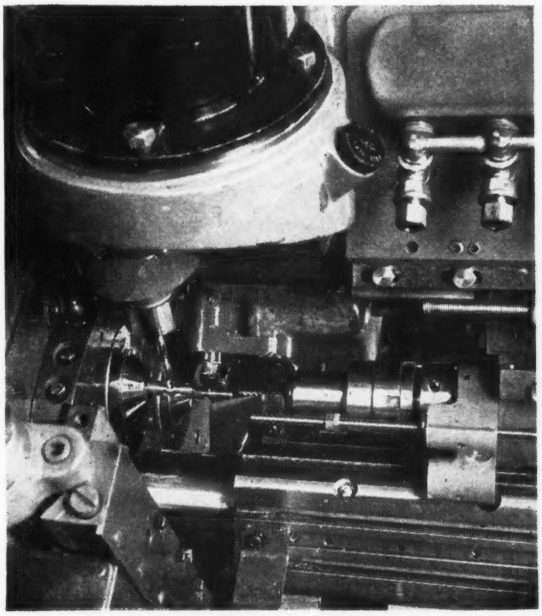

Fig. 8. Production of a snap lock socket : cross-drilling and slot-milling heads.

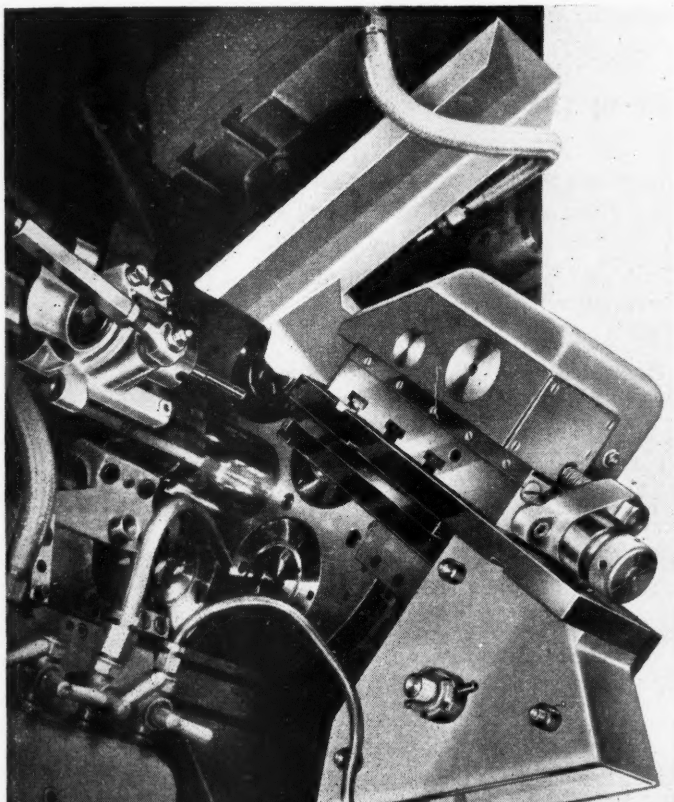

Fig. 9. An example of a magazine loading attachment

MATERIAL UTILISATION SUB-COMMITTEE

Notes for Guidance in the preparation of Case Studies

THE Research Committee, following the publication last year of their Report entitled "Material Utilisation in the Metal Working Industries", decided that similar investigations relating to other materials should be made, and the co-operation of the Institution's membership sought in carrying out this work.

Consequently a new Sub-Committee was formed and given the following Terms of Reference :-

> "To investigate, within the specified fields, the use of raw and process materials in the engineering and allied industries, and other production processes."

CONSTITUTION OF THE SUB-COMMITTEE

Mr. R. N. Marland, B.Sc., A.M.I.Mech.E., M.I.Prod.E. (Chairman),
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Mr. S. G. E. Nash, M.I.Prod.E. (Vice-Chairman),
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Mr. J. H. Bennitt, M.A., F.R.I.C.,
Assistant Development Manager, Bakelite Limited.

Mr. J. H. Gray, A.I.Mech.E.,
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Mr. A. W. Wallbank, B.Sc., F.R.I.C.,
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PANEL "A" — Finishing (painting, enamelling, lacquering, chemical finishes and plated finishes).

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Mr. J. Adcock, B.Sc., Technical Service Manager, I.C.I. Ltd. (Paints Division), Slough.

Mr. J. H. Gray, A.I.Mech.E., Managing Director, Escol Products Ltd.

Mr. J. Hooper, Editor, " Sheet Metal Industries ".

Dr. D. N. Layton, Ph.D., M.Sc., A.R.C.S., D.I.C., A.Inst.P., Technical Manager, Ionic Plating Co. Ltd.

Mr. W. F. McDonald, Production Engineer, Domestic Electronics Division, E.M.I. Ltd.

Mr. I. Walker, A.I.M., Head of Laboratories, Briggs Bodies Ltd.

Mr. A. W. Wallbank, B.Sc., F.R.I.C., Managing Director, Ionic Plating Co. Ltd.

PANEL "B"—Ancillary Materials, with particular regard to packaging, cartoning and shipping materials.

Mr. H. L. Madeley, A.M.I.Prod.E. (Chairman), Production Manager, Hoover Ltd.

Mr. K. S. Arnold, Production Engineer, S. Smith & Sons Ltd., Cricklewood.

Mr. G. W. Lord, Packaging Engineer, Rubery Owen & Co. Ltd.

Mr. F. A. Paine, B.Sc., A.R.I.C., Head of Packaging Laboratories, Printing & Allied Trades Research Association.

Mr. E. A. Shipley, B.Sc., A.I.M., Nuffield Central Research Laboratories.

Mr. R. T . Webb, A.M.I.Prod.E., Production Engineer, Philips Electrical Ltd., Mitcham Works.

PANEL " C " — Ceramics, Metal Powders and Plastics.

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Mr. G. R. Bell, B.Sc., A.R.S.M., A.R.I.C., A.I.M., Metallurgist, Powder Metallurgy Ltd.

Dr. T. H. Blakeley, B.Sc., Ph.D., M.I.Chem.E., M.Inst.Gas E., M.Inst.F., F.R.I.C., Head of Research Section, The Morgan Crucible Co. Ltd.

Mr. S. A. Ede, F.P.I., Technical Director, James Ferguson & Sons Ltd.

Mr. J. E. Poulter, A.M.I.Prod.E., Works Superintendent, Doulton Industrial Porcelains Ltd.

Mr. R. Smith, A. G. Hayek & Partners Ltd.

PANEL "D" — Indirect Materials (e.g., degreasing solutions, wetting agents, lubricants, cutting oils, etc).

Mr. B. G. L. Jackman, A.R.Ae.S., M.I.Prod.E., M.I.I.A. (Chairman), General Manager, Brakes Division, Lockheed Hydraulic Brake Co. Ltd.

Mr. H. H. Beeny, M.Met., F.I.M., M.I.S.I., M.I.B.F., Works Metallurgist and Research Engineer, Alfred Herbert Ltd.

Mr. W. F. McDonald, Production Engineer, Domestic Electronics Division, E.M.I. Ltd.

Mr. H. L. Quick, A.I.M., Assistant Chief Metallurgist and Chemist, Humber Ltd.

Mr. H. Stafford, M.I.Mech.E., A.M.I.Prod.E., Standards Engineer, The United Steel Co. Ltd.

Mr. A. Taylor, B.Sc., F.R.I.C., Head of Products Development Department, F. W. Berk & Co. Ltd.

Mr. R. Tilsley, A.M.I.Mech.E., A.M.I.Prod.E., Research Manager, Production Engineering Research Association.

Mr. J. R. Widdowson, M.I.Prod.E., Chief Production Engineer, Samuel Fox & Co. Ltd.

PANEL " A " ON FINISHING

Suggested Notes for Guidance

Materials Economy

Many different finishing systems are applied to manufactured articles to provide protection against corrosive conditions, resistance to wear or attractive appearance. Economies in the use of such applied finishing materials may be achieved in several different ways, chief of which are :-

1. Design of component so as to ensure uniformity of coating, ease of processing and avoidance of loss of process materials by reason of the geometry of the article.

2. Careful planning of finishing process to avoid unnecessary wastage of process materials, contamination of materials and high incidence of rejects.

3. Good housekeeping, i.e., the reclamation of waste materials in such a form that they can be used again or sold as scrap.

4. Careful specification of the finish required so as to avoid use of unnecessarily expensive materials or excessive quantities of materials.

Economies in raw materials may also be effected by thought given to finishing processes.

Analysis of Field considered as covered by the Finishing Panel

1. Surface cleaning and conditioning prior to finishing process.

2. Painting.

3. Vitreous enamel finishes.

4. Electroplating and chemical finishes.

Amplification of the main headings

1. Surface cleaning and conditioning

(a) *Mechanical processes — prior to surface cleaning*

Such processes as grinding, wire brushing, grit or shot blasting, steam or flame jet, tumbling, buffing and polishing. Scale or heavy rust may also be removed by pickling.

(b) *Degreasing prior to finishing*

The general classes of oils and greases to be removed are :-

(i) Non-saponifiable or mineral oils, such as petroleum hydrocarbon lubricants.
(ii) Saponifiable or vegetable and animal oils and fats, mixtures of these with resins, and also tallow.
(iii) Sulphonated or sulphurised oils.
(iv) Chlorinated oils and mixtures of any of these.

These may be removed by one or more of the following processes :-

(v) Alkaline Cleaners.
(vi) Emulsion Cleaners.
(vii) Solvent Wash.
(viii) Solvent Vapour.
(ix) Electrolytic Cleaning.

(c) *Chemical Pretreatments*

2. Painting

(a) *Choice of Paint System*

Type of finishing material such as Cellulose, Oleo-resinous or Synthetic Resin ; use of Primer, Undercoat and/or Stopper.

(b) *Surface Cleaning and Chemical Pretreatment*

Processes and materials as detailed under 1 (b) also chemical pretreatments such as Acid Etch, Phosphate Coating, Chromate Coating and Anodised Coating.

(c) *Method of Application*

Brushing, spraying, dipping, flow-coating, roller-coating and barrel tumbling. Spray application should be considered under the headings of, Manual, Automatic, Electrostatic

and Airless, and Hot Spray methods can be employed with Manual and Automatic spray application.

(d) *Drying and Stoving of Paint Films*

Convection methods comprising superheated steam and high pressure hot water (without forced circulation), direct fired ovens and indirect fired ovens. Radiation methods comprising gas heated radiant panels, electrically heated sheathed elements and electrically heated lamps. Combinations of convection and radiation processes can also be employed.

3. Vitreous Enamel Finishes

(a) *Design of the Components*

A specialised subject, but copies of a technical brochure entitled "Design for Vitreous Enamelling" are available on request from the Institution of Production Engineers, 10 Chesterfield Street, London, W.1.

(b) *Pretreatment*

Processes for sheet iron or cast iron are standard throughout the industry.

(c) *Choice of Finishes*

Many special finishes are available to suit varying industrial requirements.

4. Electroplating and Chemical Finishes and Applied Metal Coatings

This section is intended to include such processes as electrolytic zinc process, tinned and nickel sheet, strip galvanising, tin dipping and spraying.

(a) *Design of Component*

Economy of deposited metal, economy of processing solutions, economy of ancillary solutions and use of cheaper base metal, eletroplated instead of more expensive material of construction.

(b) *Design of Process*

Attention jigging and anode arrangement, automatic controls, use of recovery rinses, design of anodes and method of working and use of scrap portions of anodes. Use of cheaper process materials, e.g., sodium rather than potassium. Use of plating solutions having levelling properties to reduce polishing operations. Economy by using chemical polishing and brightening.

(c) *Design of Specification*

Choice of correct protective metal for service environments and control on thickness of metal applied.

(d) *Electro Plating and Chemical and Applied Metal Coatings.*

PANEL "B" ON ANCILLARY MATERIALS

Packaging, Cartoning and Shipping Materials

Considerable attention has always been directed by the production engineer towards methods of production and manufacturing processes generally, but in many instances this stops at the finished product stage; whereas, in actual fact, another 5% or 10% added cost may be involved before the goods can arrive safely at their destination, quite apart from insurance premiums which are based on past risk experience.

The following Notes for Guidance are the essential factors to be considered by production engineers in order to achieve satisfactory results. In addition, by examples and case studies, it will advise how maximum material utilisation may be achieved with economy in cost.

The field of study can be divided under four main sub-headings :-

I. Selection of Packing Materials and Methods

1. Crates and cases (wooden)—returnable.
2. Crates and cases (wooden)—non-returnable.
3. Metal containers—paint, etc.
4. Bulk delivery—liquids.
5. Cardboard cartons.
6. Cartons—Unit packaging.
7. Palletisation.
8. Protective coatings or coverings :-
   (a) Wax dipping.
   (b) Synthetic coating.
   (c) Cellulose or plastic film.
   (d) Hessian covers.
9. Automatic packaging equipment, including automatic nailing and stapling.
10. Wire and steel banding.
11. Advice available from research organisations.

Considerable improvements have been made in the strength of solid and corrugated board and probably the greatest proportion of manufactured products are shipped in cartons of one sort or another.

Sealed metal containers and drums are used in many instances. Considerable savings have been effected by large users changing to bulk container deliveries.

Similarly, by the introduction of synthetic coatings and wax coatings, many products and spare parts are now sent out without the necessity of packing in cases and cartons.

Many examples could be quoted where extensive savings have resulted by changing from individual to multiple packs and also where, by joint collaboration with a customer, a system of returnable packages has been effected which has proved of mutual benefit.

II. Design of Product and Effect on Packaging Requirements

1. Attention to nature of product — whether fragile, etc.
2. Finish of product and reaction during transit.
3. Protection for finished surfaces.

Numerous examples could be given where — due to lack of consideration during the early design stages — a more difficult problem has been created for packaging and shipping, e.g., early consideration of the physical shape of an article may help to reduce the ultimate packaging costs.

Similarly, much money can be wasted and customer dissatisfaction invited by insufficient care being taken to ensure that fine finishes are going to stand the conditions to which they are subjected on, for instance, a journey to Australia or South America.

III. Influence of Handling and Transit Methods

1. Rail transport.
2. Use of shipping containers.
3. Direct road services.
4. Overseas and export — effect of humidity and salt water ; need for special precautions such as inhibitors, etc.
5. Collaboration between manufacturer and customer, or inter-works handling.
6. Economics of weight and volume in transport costs.

Much of what has been stated under heading II applies to this section also. There are, however, many alternative methods which can be considered. For instance, the shipping container has the advantage that it can be delivered to the manufacturer's premises and packed under his own supervision, with the knowledge that the contents will not be disturbed until discharged at the receiving end.

For home market despatches many firms have developed their own delivery services, so that handling may be reduced to a minimum and, in many cases, the extent of protection provided need only be very small indeed.

Experience has also shown that it is very often better to build up a unit package of such dimensions that either a crane or fork-lift truck is required for handling, rather than a single package that may be manhandled or dropped.

IV. Presentation of Product and its Shelf Life

1. Appearance of package or carton.
2. Advertising and display value.
3. Rate of turnover of product and its shelf life.

To provide a satisfactory solution to many packaging problems the period of shelf life or storage in bond must be known, as it is false economy to attempt to make savings which will ultimately impair the quality of the goods involved.

So far as the presentation of the product is concerned, there are many classes of goods which have to stand on display, and in these cases it has often been found possible, without incurring further expense, to design a method of cartoning or packaging which also has advertising and display value.

PANEL "C" ON

CERAMICS, METAL POWDERS, PLASTICS

Suggested Notes for Guidance

Sections are invited to provide case studies indicating savings achieved in, or advantages arising from, any aspect of the utilisation of *Ceramics, Metal Powders* or *Plastics.*

Wherever possible, case studies should include a sketch, which may be rough and freehand, and actual or percentage figures for savings in cost, in weight of material, or in process time.

Aspects from which material utilisation should be viewed include :

1. Consideration at the design stage of the choice of material leading to savings.

2. How best to use the material, knowing its properties, in association with other components.

3. The actual use of the material in the most economical way.

4. Improvement in performance, due to correct choice of material.

Ceramics, including Glass and Carbon

Ceramic manufacturing processes by which savings may be achieved include :-

Forming, e.g., by casting, extrusion, die pressing, turning, grinding.

Surface Finishing, e.g., by glazing.

Decoration and Marking, e.g., by body colour, under-glazed printing, coloured glazing or transfer.

Metal Powders

Metal powder processes by which savings may be achieved include :-

Forming, by cold pressing or extrusion, both followed by sintering or hot pressing.

Sintered Parts. Porous self-lubricating bearings and bushings, engineering components such as gears and cams, refractory metal products, magnets, composite metals, ceramics, friction materials, etc.

Specialised Uses, e.g., metal spraying, brazing materials, calorizing, paint pigments and impact or peen plating.

Plastics

Plastics processes by which savings may be achieved include :-

Manufacture, e.g., by compression, injection or transfer moulding, by extrusion, calendering, casting, turning, grinding, etc.

Utilisation, e.g., in assembling or fixing.

Selection, e.g., of one material or grade instead of another to improve output or quality.

PANEL "D" ON

INDIRECT AND PROCESS MATERIALS

Economies in the use of various process materials can occur in many different ways, and they are not confined merely to using less of a particular consumable material or the replacement by a cheaper material of similar performance.

It is conceivable that a more expensive process, giving much longer satisfactory working life to the product than any previous process, could be ranked as an economy overall.

Also, factors like greater cleanliness, increased safety and health characteristics, smaller floor area and greater degree of standardisation can all be counted as positive progress of the type desired.

In presenting information, the case study method is preferred, giving chapter and verse of the procedure before and after the change, together with, wherever possible, the financial saving or increased life resulting from same.

It has been decided to exclude from this section all forms of fuel and its usage in industry, although this might well form a further research subject at a later date. The Panel also gave considerable thought to the question of including welding rods, solders and brazing materials, and abrasive and cut-off wheels, but it was agreed that these might well form the subjects of separate sections in the future.

Analysis of Field Considered as Covered by Panel "D"

I. Lubricants, with particular reference to machine tool, press-working, steel, automobile, electrical and plastics industries.

II. Cutting fluids, with particular reference as in I above.

III. Surface cleaning and conditioning (including degreasing, dewatering and anti-corrosion chemical processes).

IV. Temporary protective coatings.

V. Quenching oils and tempering media.

VI. Use of water in industry (water condition or quality).

Amplification of the above Material Categories

I. Lubricants

(a) *Fluids*

(i) Mineral oils — general purpose.

(ii) Chemically reinforced oils — running in of sliding surfaces; special oils for corrosion prevention in tropical climates; lubrication for high speed working; low viscosity reinforced oils.

(iii) Colloidal graphite — use in glass industry and others.

(iv) Lubricants for presswork, forming and cutting.

(b) *Semi-solid (greases)*

(i) General purpose greases, e.g., lime soap and soda.

(ii) High speed and non-separating greases.

(iii) High temperature greases, e.g., lithium, bentone.

(iv) Water-resistant greases, e.g., silicone, bentone, calcium soap.

(v) Chemical-resistant greases.

(vi) Assembly greases, e.g., molybdenum disulphide in a carrying agent.

(vii) Multi-purpose greases.

(c) *Solids*

such as molybdenum disulphide powder, flake graphite and polytetrafluoroethylene.

(d) *Hydraulic Fluids*

as such, or combining hydraulic and lubricating properties. Non-inflammable type for high pressure process machines. Braking systems.

II. Cutting Fluids

(a) *Neat Cutting Oils*

for autos and thread grinding, broaching, tapping, etc.
Vast number of branded oils available including those using low fat content and chemical additives. Attention needed as regards method of application, fuming, reclamation, and skin protection.

(b) *Cutting and Grinding Fluids*

Oily and non-oily types. Special attention needed with anti-corrosion properties, mixing and distribution.

(c) *Gaseous Coolants*

Carbon dioxide for tool tip cooling; oil mist cooling.

(d) *Special Shaping Process Materials*

e.g., dielectric fluids (paraffin, etc.) for spark erosion cutting. Abrasive fluids for ultrasonic cutting of non-conducting materials.

III. Surface Cleaning and Conditioning

(a) Descaling, derusting and deburring (non-manual), using shot or sand blasting, vapour blast, drum cleaning, pickling and other descaling fluids, electro-cleaning, sodium hydride. Electrolytes for electro-polishing.

(b) Non-automatic or semi-manual methods of surface preparation, including fettling, grinding and polishing.

(c) Cleaning and degreasing. Paraffin, trichlorethylene, hot soda, detergent solutions, white spirit.

(d) Dewatering agents. Useful for short period protection, including white spirit, hot water emulsions.

(e) Wetting agents. For full surface coverage and swilling operations.

(f) Metal spraying and hard surfacing.

IV. Temporary Protective Coatings

(a) Hard film, brush, spray or dip applied.

(b) Soft film, brush, spray or dip applied.

(c) Strippable plastic coatings.

(d) Impregnated papers.

(e) Dewatering agents (see III (d) above).

V. Heat Treatment Media

(a) Oils — quenching and tempering.

(b) Carburising compounds (including gas carburising).

(c) Salt and metal baths.

VI. Use of Water in Industry

(a) Conservation — circulating pits, coolers, etc.

(b) Water treatment equipment for large installations, e.g., lime soda plus phosphate.

(c) Isolated small water systems.

(d) Systematic water testing.

(e) Addition to corrosion inhibitors and lubrication to water systems.

Members or companies who would like to collaborate in the work of this Sub-Committee are invited to get in touch with the Secretary, 10 Chesterfield Street, London, W.1, or their own Section Honorary Secretaries.

HIGH SPEED PRODUCTION FROM BAR MATERIAL — *concluded from page 523*

arrangement allows the operator to throw the components into the hopper, the one illustrated was employed as a means of stacking a large quantity of work into a hopper for eventual feeding into a conventional gravity chute. The capacity of the hopper illustrated is approximately 100 components, giving a running period of about 40 minutes. A pneumatic vibrator is fitted to the side of the hopper, comprising a single acting air cylinder actuated through a relay valve. This is to prevent the components jamming, and shakes them up every 4 seconds. Limit switches are used to stop the machine, if, for instance, the component should be inserted the wrong way round when producing the second stage, or should an endwise jam occur when loading the pieces into the collet. The installation of a machine thus equipped has, in one case, released four capstan lathes which had produced on a 4½ minute time cycle 8,00 pieces in about 330 hours, compared with the automatic's rate of 8,300 pieces in about 100 working hours ; 71½% efficiency is obtained, 20% being allowed for contingencies, which gives an overall production of 83 pieces an hour. This illustrates quite clearly how savings can be obtained by fitting properly conceived and efficiently designed feeding devices. A less usual type of feeding arrangement is a chain type conveyor where a plain gravity chute is impracticable ; the components are carried in clips or U-shaped pieces attached to the chain links, the conveyor being indexed from one position to another by the linear movement.

It will be apparent that the field covered by bar automatics is an immensely wide one, ranging from the minute piece produced by the sliding head automatic, with its great accuracy, and the small parts turned out by the automatic screw machine, to the infinite variety of components, large and small, which lie within the scope of the multi-spindle automatic. Cycle times vary from 1 second (or less) to about 15 minutes. It must be emphasised that the time taken to produce a component is governed by the complexity of the job and the nature and design of the tools used. Recent research seems to show that the use of tungsten carbide tools will allow output to be still further increased from existing machines, though many problems which still remain to be solved in this field make it impossible for the subject to be treated in this Paper.

institution notes

FORMATION OF THE MATERIALS HANDLING GROUP

Members will have seen in the July issue of the Journal the announcement on the formation of the Materials Handling Group. The Committee of this Group have since met several times and have agreed conditions for membership of the Group. These are reproduced below :-

1. A member of the Materials Handling Group must be a Graduate, Associate or Corporate member of the Institution. Student members of the Institution will not be eligible for membership of the Materials Handling Group but will be actively encouraged to participate in all its activities.

2. For the time being, the Materials Handling Group will admit to membership any Graduate, Associate or Corporate member of the Institution who can satisfy the Group Committee that by reason of his past background and experience and/or by reason of his present duties and interests he has concerned himself specifically with the Materials Handling aspects of production engineering. Moreover, any candidate member for the Materials Handling Group must be prepared to contribute actively to the work of study and advancement in their chosen subject which will be undertaken by the Group.

Region and Section Representatives of the Materials Handling Group

3. A Region or Section Representative of the Materials Handling Group should be a member of his Region (or Section) Committee ; if not, he should be of the standing which will ensure that his Region (or Section) Committee will welcome his attendance at those of their meetings at which matters regarding the Materials Handling development within the Institution form part of the agenda.

4. A Region or Section Representative must be prepared to devote time and energy to the organisation of Materials Handling activity within the area of his Committee. In the case of Region Representatives this will involve the co-ordination of Section activities and their active encouragement. In the case of Section Representatives this will involve verification of and comment upon the applications for membership of the Materials Handling Group from Graduates, Associates and Corporate members of the Institution within his Section, thus allowing the central Committee of the Group to judge effectively such individual applications before confirming membership.

5. It is envisaged that Section Representatives will form into a Sub-Group all members of the Materials Handling Group within their Section, once a large enough number has been reached. This Sub-Group will act as the specialist body on Materials Handling within their Section and will organise and conduct activities as appropriate, not only for members of their Sub-Group but also for all other Institution members in their area. Where appropriate they will liaise and co-ordinate functions with other bodies concerned with Materials Handling activities in their area (e.g. the chartered engineering institutions, the Institute of Materials Handling, the local Productivity Committee, the Institute of Works Managers, etc.).

6. A Region or Section Representative must be prepared to attend each year the two or three meetings which will be held for them by the central Committee of the Materials Handling Group.

The Committee of the Group have already invited Chairmen of all Regions and Sections of the Institution to nominate their representative on the Materials Handling Group. It is hoped that all of them will be able to attend the Special Meeting and Convention at Leamington Spa from 28th - 30th October, details of which are published in the Supplement to this issue of the Journal. It is also hoped that all other members of the Institution interested in the subject of Materials Handling will attend the Convention.

BIRTHDAY HONOURS

Members of the Council will be pleased to learn that Her Majesty the Queen has conferred the following awards on members of the Institution :

Knight Bachelor

Mr. William Scott, Member, Managing Director, Armstrong Whitworth Metal Industries.

M.B.E

Mr. R. G. Winton, Associate Member, Director and Technical Manager, Lansing Bagnall Ltd.

NEWS OF MEMBERS.

Mr. Frank Guylee, Member, has recently retired as Managing Director of Frank Guylee & Son Ltd., Sheffield, but retains his interest in the Company as Chairman. His son, Mr. Arthur Norman Guylee, Associate Member, has been appointed Managing Director.

Mr. F. Guylee

Mr. A. N. Guylee

Mr. F. Koenigsberger, Member, has been appointed Reader in Machine Tools and Production Processes in the Faculty of Technology, Manchester University.

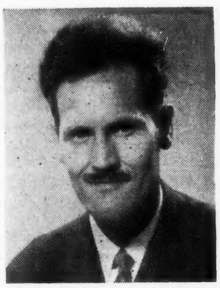
Sir Walter Puckey, Member, has joined the Board of Black and Decker Limited.

Mr. W. O. Bell, Associate Member, formerly acting Production Director of Black and Decker Limited, is now Production Director.

Mr. G. F. P. Fox, Associate Member, has relinquished his appointment with Rolls-Royce Limited, and has taken up an appointment as Manager, Sales Development with the Climax Molybdenum Company of Europe, Sheffield.

Mr. J. G. H. Pearce, Associate Member, has taken up a position as Organisation and Methods Controller with Rotol Limited.

Mr. J. F. Westaway, Associate Member, has recently taken up an appointment as Works Manager at Westool Limited, Bishop Auckland, Co. Durham. Mr. Westaway was previously Assistant Works Manager with Messrs. Wild-Barfield Electric Furnaces Limited, of Watford.



Mr. B. R. Westwell, Associate Member, has been appointed Factory Manager of the Metal Box Company (B.W.I.) Limited, Kingston, Jamaica.

Mr. S. F. Forshaw, Graduate, has recently moved to the Blackburn Works of Mullard Limited, as a Technical Estimator.

Mr. B. P. Hayward, Graduate, has relinquished his appointment in the Electronics Research Laboratory of the Birmingham Small Arms Company Limited, to take charge of research and development in resistance welding and allied processes, with the Joining Process Laboratory of Messrs. Joseph Lucas Limited, Birmingham.

THE 1957
SIR ALFRED HERBERT PAPER

Members are reminded that the 1957 Sir Alfred Herbert Paper will be presented at the Royal Institution, London, on 31st October next.

The speaker will be Dr. H. Barrell, Head of the Metrology Department of the National Physical Laboratory, who will take as his subject: "The Bases of Measurement".

An application form for tickets is included in the Supplement to this Journal.

Hazleton Memorial Library

REVIEW & ADDITIONS

REVIEW

"Drawing Office Handbook", edited by R. W. Stuart Mitchell. Published under the auspices of the Drawing Office Material Manufacturers' and Dealers' Association. 3rd edition. *London, Pitman,* 1956. 423 *pages.* 16s.

Some years ago the British Standards Institution published "British Standards for Workshop Practice", which contained abridged versions of British Standards considered useful to the designer and manufacturer. In its original form the book was invaluable, but unfortunately the current edition caters for only a small section of the metal cutting industry, and to the majority of engineers is almost useless. I am therefore delighted to find that the editor of "The Drawing Office Handbook" was, like myself, impressed by the first edition.

"The Drawing Office Handbook" includes abridged and expanded versions of most Standards which are necessary to the work of a mechanical engineer. Splines and serrations, surface finish, and the sizes of small holes have been excluded, but to make up for this omission, information about the specification of aircraft materials is included — a great help to engineers in the aircraft industry.

Besides the section on standards the book includes sections on mechanical design, electrical design, and much useful general information. The treatment is comprehensive and authoritative. As an example of the scope of the individual sections, the section on Mechanical Design comprises more than 200 pages, from which a working knowledge of the subjects treated can be obtained:

1. Design Formulae (bending, section modulus — polar moment of inertia — struts and columns, deflection of flat plates, etc.).
2. Properties of materials.
3. Welding.
4. Mechanical power transmission (including such things as whirling of shafts).
5. Gear design.
6. Springs.
7. Lubrication (including answers to such questions as "grease or oil?").
8. Mechanical vibration.
9. Noise.

Other sections are similarly comprehensive. The book even includes information about methods of reproducing drawings and about patent law.

Nobody can be a good production engineer unless he is given a sound design to work from. This book will help the intelligent draughtsman or designer to make good designs, and will enable the production engineer to make constructive suggestions to the design department, instead of the too prevalent destructive criticisms. I can strongly recommend this book to apprentices also, whether they are looking towards the design office or the shops. At 16s., this book is a bargain too good to be missed. R.E.M.

ADDITIONS

Mavor and Coulson Ltd., Glasgow. **"The Design of Belt Conveyors."** *Glasgow, the Company,* 1956. *Illustrated. Diagrams. Tables.* £2 2s. 0d. Limited circulation.

The information in this book is based on the experience of a Company which specialises on the design and manufacture of belt conveyors. The first chapter deals with the choice of belt to carry the necessary tonnage and the largest lumps. It is followed by chapters on gradients, power requirements. driving gears, choice of belting, spacing of idlers, belt take-up, loading and unloading, and tables on the density of materials and mathematical tables. The book contains a number of alignment charts, by which all the chief calculations in the design of belt conveyors can be made without the use of formulae and tables. Examples are given of the use of the charts. The book is produced in a convenient format, and is excellently indexed and guided.

Malgorn, Guy. **"Lexique Technique Anglais-Francais."** 4th edition revised. *Paris, Gauthier-Villars,* 1956. XXXIV. 493 *pages.* 21*cm.* £3 3s. 0d.

Malgorn, Guy. **"Lexique Technique Francais-Anglais."** *Paris, Gauthier-Villars,* 1956. XXVIII. 475 *pages.* 21*cm.* £3 3s. 0d.

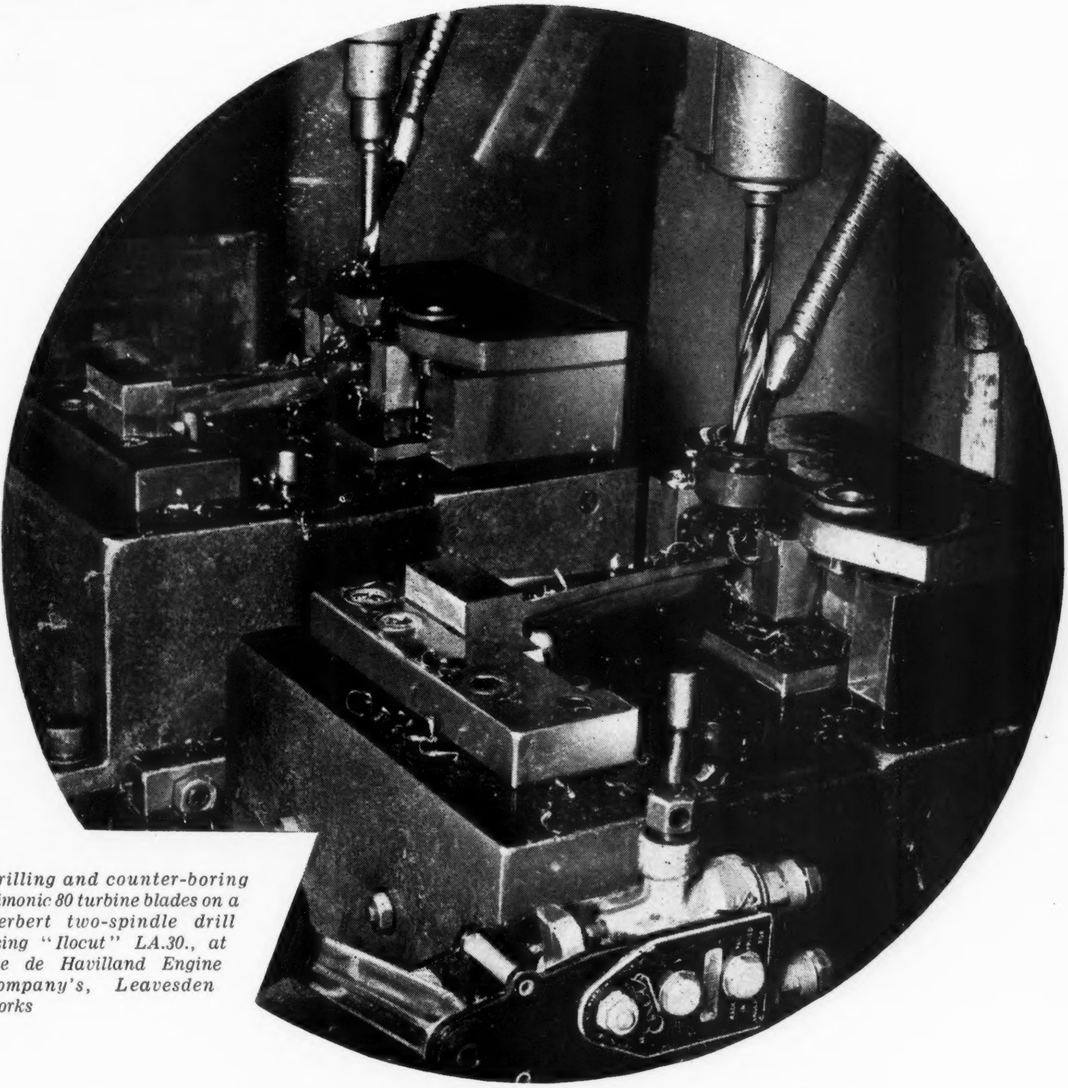
The following subjects are covered by these bi-lingual dictionaries: machine tools, mining, internal combustion engines, aeronautics, electricity, railways, naval architecture and structural engineering. Machine tools are better dealt with than in any other comprehensive technical dictionary we know. The screw thread tables and the weights and measures conversion tables are very useful.

Middleton, Helen K. (editor). **"Hydraulic Research in the United States, 1956"** ***(including contributions from Candain Laboratories).*** *Washington, Government Printing Office,* 1956. XII. 216 *pages.* 26*cm.* 15s.

Lists chronologically and describes hydraulic research projects, at universities and other organisations. Alphabetical subject index.

Polushkin, E. P. **"Defects and Failures of Metals: Their Origin and Elimination."** *Amsterdam, etc., Elesevier Publishing Co.,* 1956. XVI. 399 *pages. Illustrated. Diagrams.* 23*cm.* £3 12s. 0d. (British distributors: Cleaver-Hume Press Ltd)

A general introduction on the interpretation of evidence is followed by chapters on segregation, blowholes and porosity of metals, pipe, impurities of metals, decarburisation of steel, scaling, harmful effects of residual stresses in metals, fatigue, flakes, failures in heat treatment, embrittlement, origin of cracks, defects in shape, surface and size, wear and corrosion. The material in each chapter is presented in standardised form, under each of six sections when relevant: definition and general characteristics of the defect; origin, causes and contributing factors; means of discovery and identification; methods of testing; occurrence, most common location of defect or susceptibility to it; detrimental effects; prevention, correction and elimination. The excellently arranged guides to literature at the end of each chapter, provide in some cases an exhaustive bibliography of the subject.



Drilling and counter-boring Nimonic 80 turbine blades on a Herbert two-spindle drill using "Ilocut" LA.30., at the de Havilland Engine Company's, Leavesden works

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1957/58

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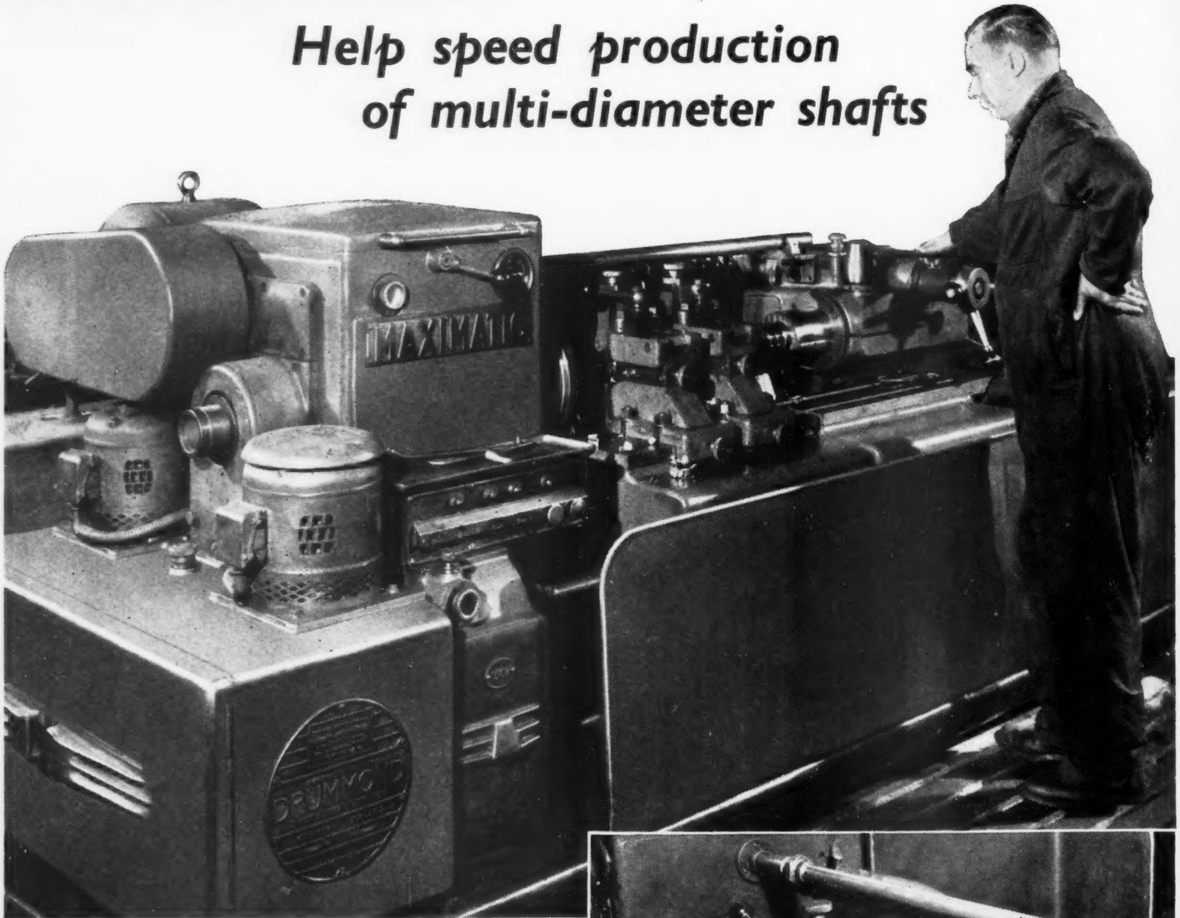

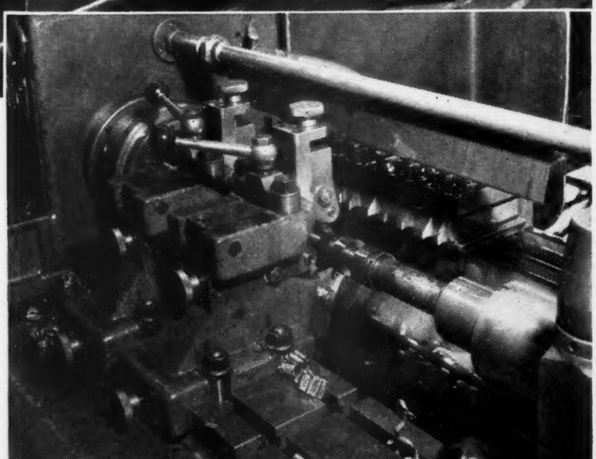

The "Maximatic" is shown tooled-up for turning steel camshafts. The operator's duties consist simply of unloading, loading and operating the main control lever. The tool slide carries out an automatic cycle of quick infeed, turn and quick return. All motors then stop ready for the component to be removed.

In the example shown, only the rear slide is employed for turning, but a combination of slides can be used for both turning and facing, each cross slide being independently operated by flat former plates, and adjustment can readily be made when a different component is required.

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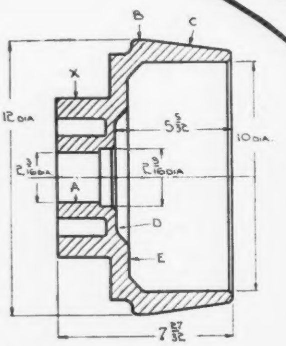
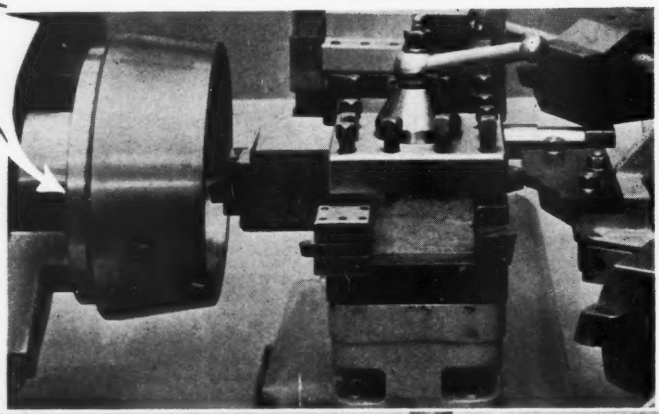
Maximum Production Special Tool Layouts

CLUTCH





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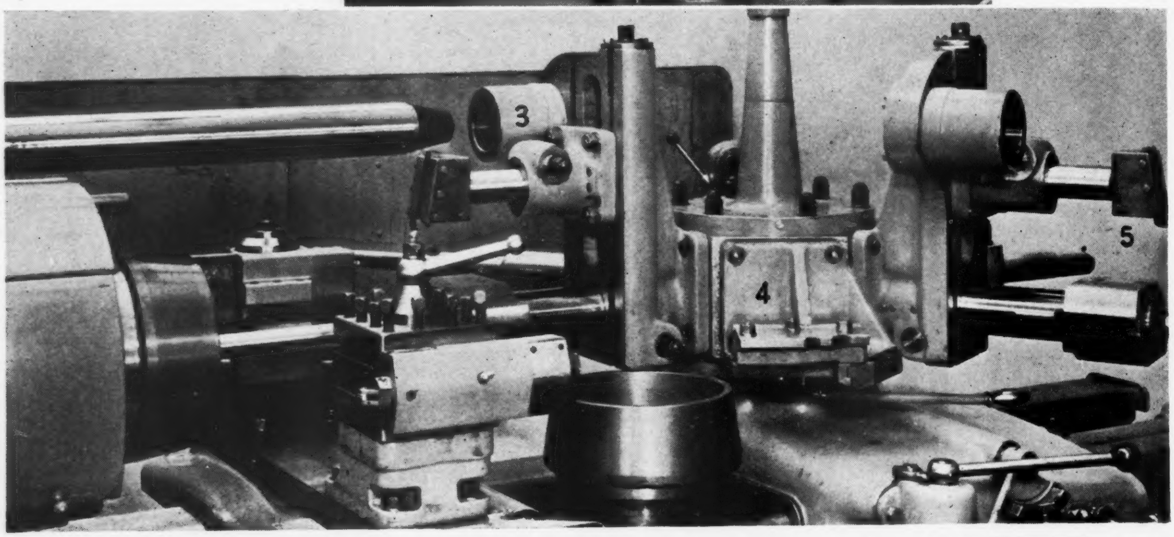
Floor-to-Floor Time: $17\frac{1}{2}$ mins. each.

Tungsten Carbide Cutting Tools



DESCRIPTION OF OPERATION	Tool Position: Hex. Turret	Tool Position: Cross-slide	Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
1. Chuck on X (using Loading Attachment)	1	—	—	—	Hand
2. Rough Bore A & $2\frac{9}{16}''$ dia. and Chamfer	2	—	375	260	64
3. Face (2 Cuts)	—	Front 1	93	278	64
4. Rough Bore 10" dia. Rough Knee Turn B and Rough Taper Turn C	— 3	— Rear	75	240	44
5. Contour Face D & E (Rough & Finish)	4	Front 3	93/125	242/325	64
6. Finish Bore 10" Finish Knee Turn B and Finish Taper Turn C and Chamfer 10" dia.	— 5	— Rear	125	390	64
7. Chamfer Outside Dias.	—	Front 2	125	390	Hand
8. Finish Microbore $2\frac{3}{16}''$ dia.	6	—	580	333	88
9. Remove (using Attachment)	1	—	—	—	Hand

Ward

No. 10 TURRET LATHE

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(13 min)
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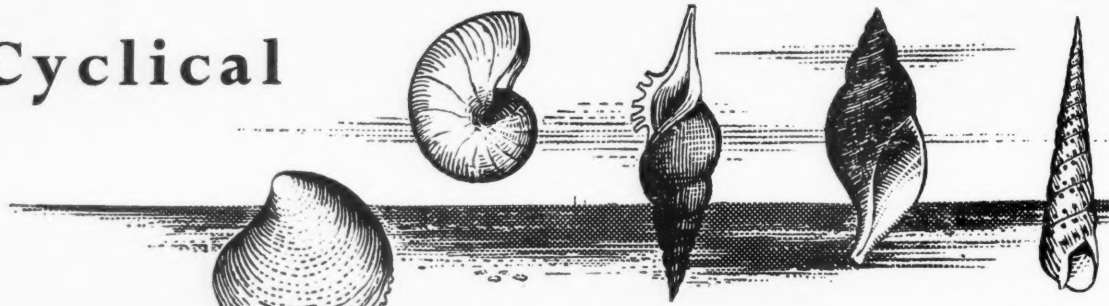

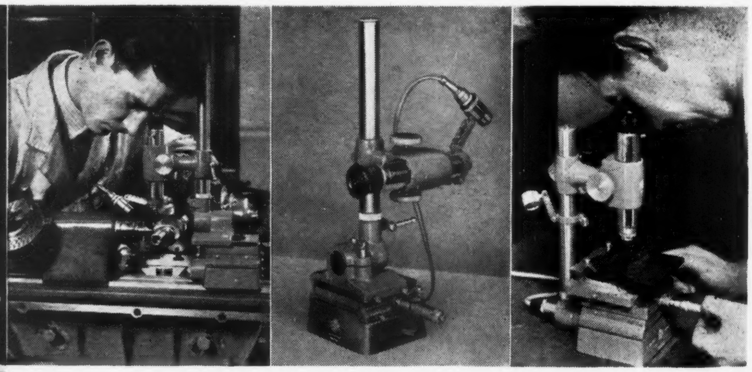

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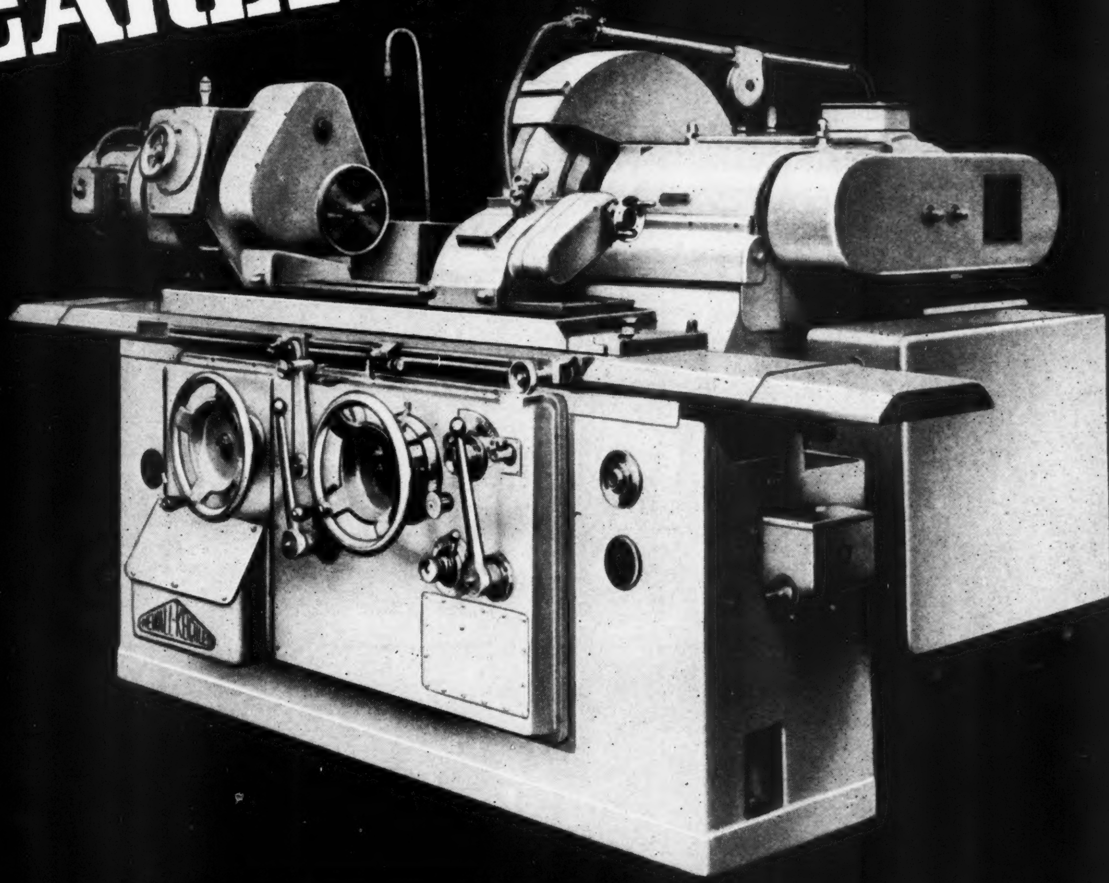

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12" x 48"	12" x 60"

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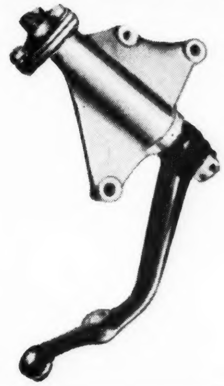

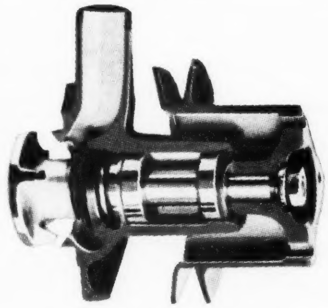

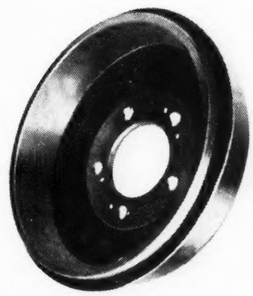

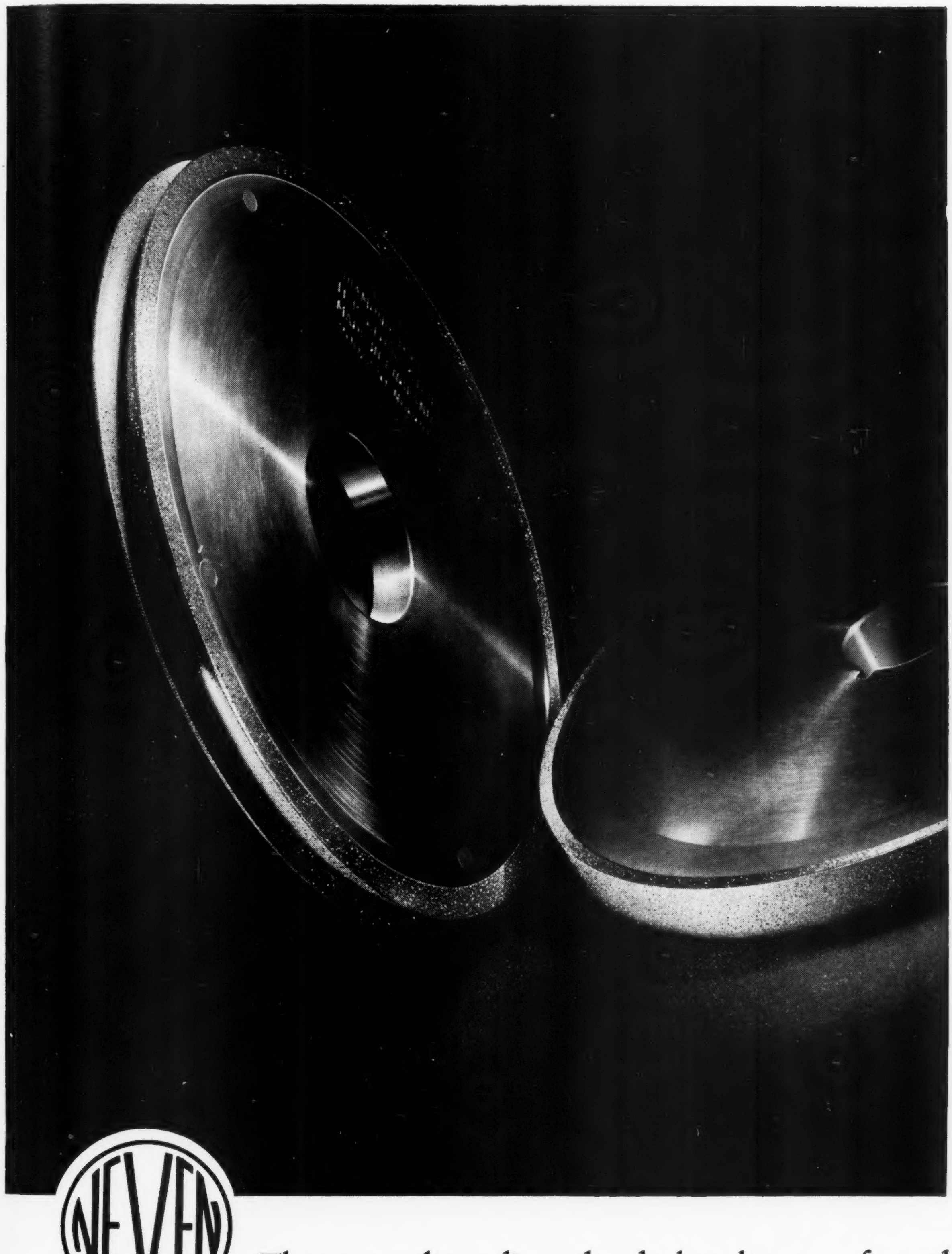

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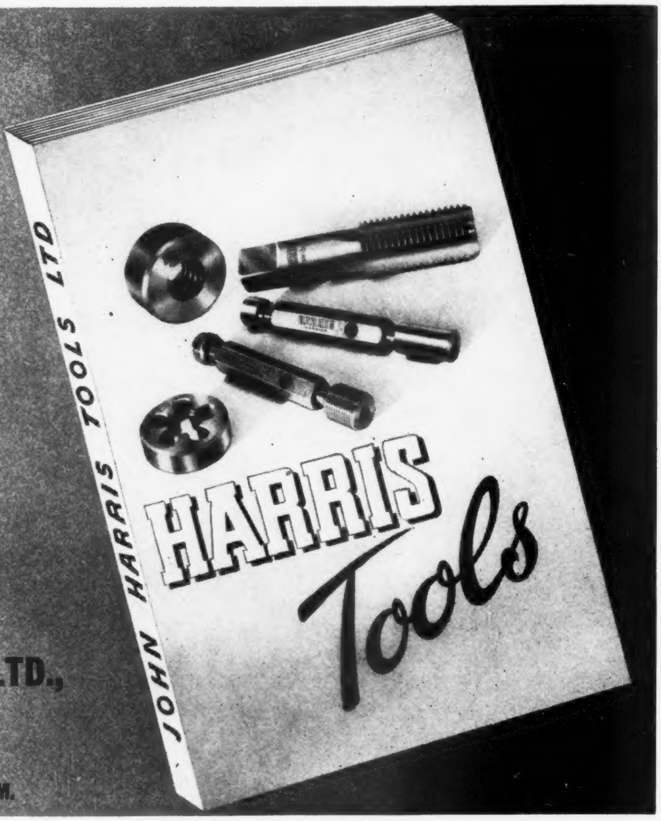

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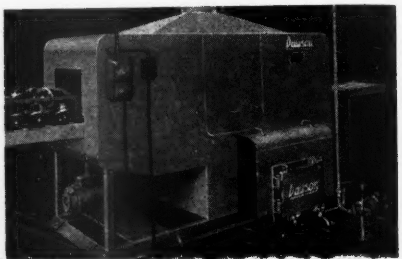

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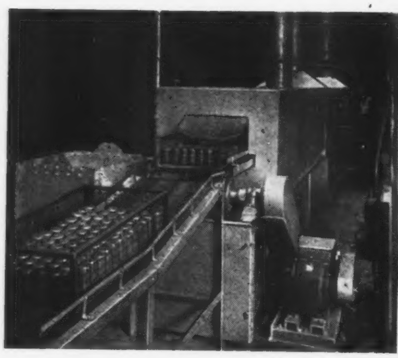

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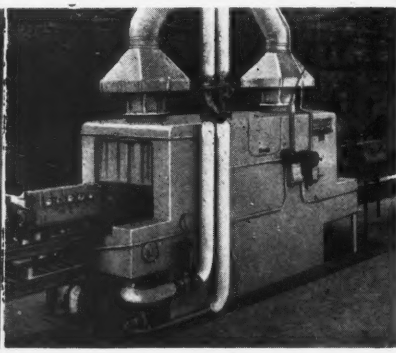

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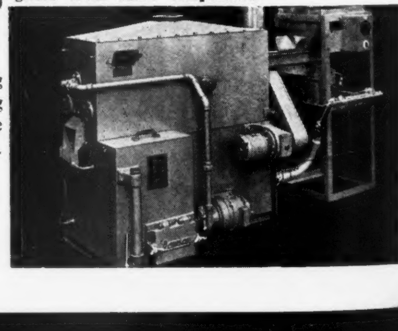

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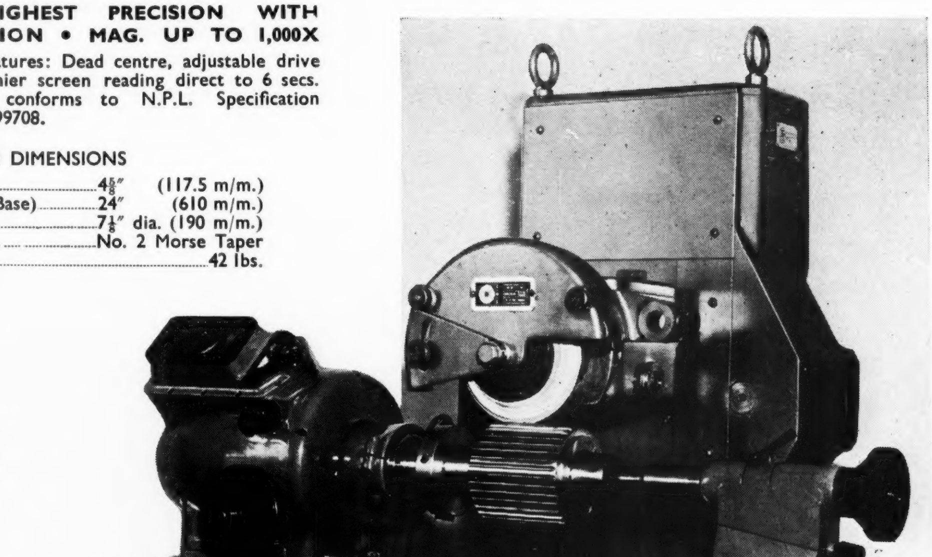

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